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Developments In a Steel Mill's Power Plant Equipment

CENTRIFUGAL PUMPS, TURBINE BLOWERS, AN IMMENSE WATER TREATING SYSTEM AND BITUMINOUS GAS PRODUCERS ARE AMONG THE RECENTLY INSTALLED MACHINERY OF THE YOUNGSTOWN SHEET & TUBE CO.

IN GOING through boiler rooms, generator rooms and pump houses of this great works, probably the most noticeable feature of the power plant equipment is the trend towards steam turbines, centrifugal pumps and rotary air compressors. For the generation of electricity, pumping water for various services and compressing air for converters and blast furnaces, machinery of the rotating type is being used to good advantage.

A water softening system of huge proportions and automatic bituminous gas producers are among other improvements which would attract the interest of an engineer visiting the plant of the Youngstown Sheet & Tube Co. at East Youngstown, Ohio.

CENTRIFUGAL PUMPS

IN No. 10 Pump House are 3 motor-driven units. Number 1 is a Wilson-Snyder centrifugal pump with a capacity of 14,000 gal. per minute driven by a direct connected 550-hp. General Electric Co. induction motor run on 6600 volts, 3-phase, 25 cycles, and delivers to the 55-lb. service line. Numbers 2 and 3 are similar in capacity to No. 1, but are driven by 2 50-hp. General Electric Co. induction motors at 220 volts, and furnish condenser water at 25 lb. pressure for No. 2 blooming mill, sheet bar and billet mill, Nos. 1 and 2 skelp mills and No. 1 power house.

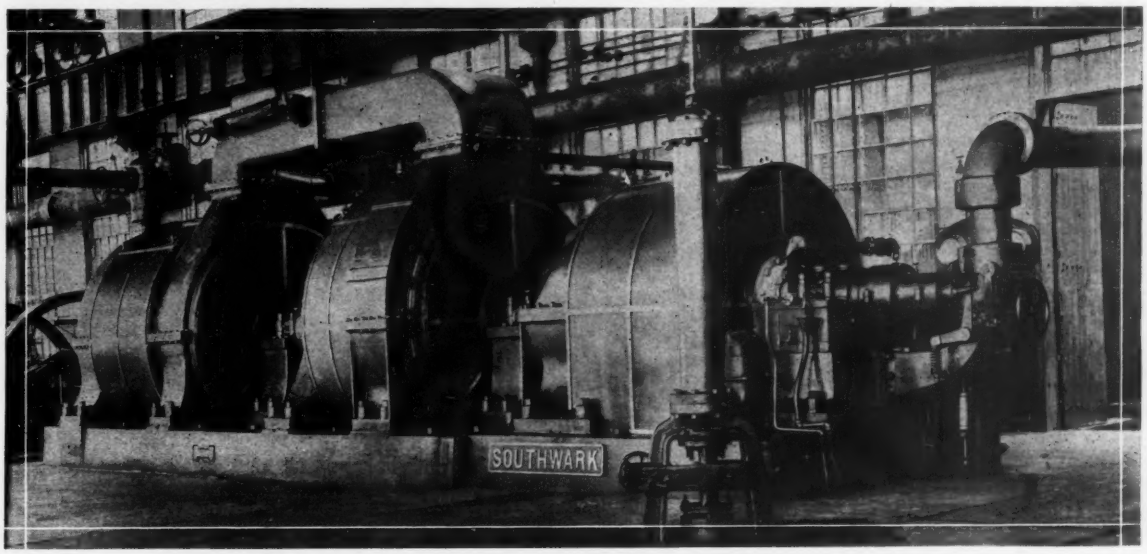


FIG. 2. TURBO BLOWER SUPPLYING AIR TO THE BLAST FURNACES

Another feature in the development of this plant is the installation of underfeed stokers which are now being put into operation in one boiler room.

A reversing blooming mill engine which is said to be the largest for this purpose in the world, has been in operation about a year and a half and has proved exceedingly economical of steam for this class of work.

The pump house known as No. 4 contains 11 centrifugal pumps, all made by the De Laval Steam Turbine Co. Five of these pumps are driven by De Laval turbines and 4 by motors. All the water used about the plant is taken from the Mahoning River, which runs next the grounds, and these pumps deliver it to the various services as shown by the accompanying table. The pump house is in charge of an engineer and a helper on each shift, which brings the operating cost down to a minimum.

During the month of June there was 2,650,000,000 gal. of condensing water pumped in the plant, and 2,102,000,000 gal. of service water.

Absolutely reliable service has been secured from these units and their extremely satisfactory operation has led to the installation of boiler feed pumps of the centrifugal type to replace reciprocating machinery.

For the puddling mill Cahall boilers, which are 25 in number of 90 hp. capacity each, worked at 150 lb. pressure; water is supplied by 2 Epping-Carpenter centrifugal pumps, size 4 in., 3-stage, driven by Kerr turbines, direct connected, which give a discharge pressure of 190 lb.

Provision is being made for the installation of centrifugal turbine driven boiler feed pumps in No. 3 boiler house, which will be Worthington pumps direct connected to Kerr turbines.

Turbine Blowers

During the past 8 yr., turbine blowers for converters and blast furnaces have reached a high degree of perfection, which makes them positive and reliable. In this plant are 2 turbine blowers made by the Southwark Foundry & Machine Co.

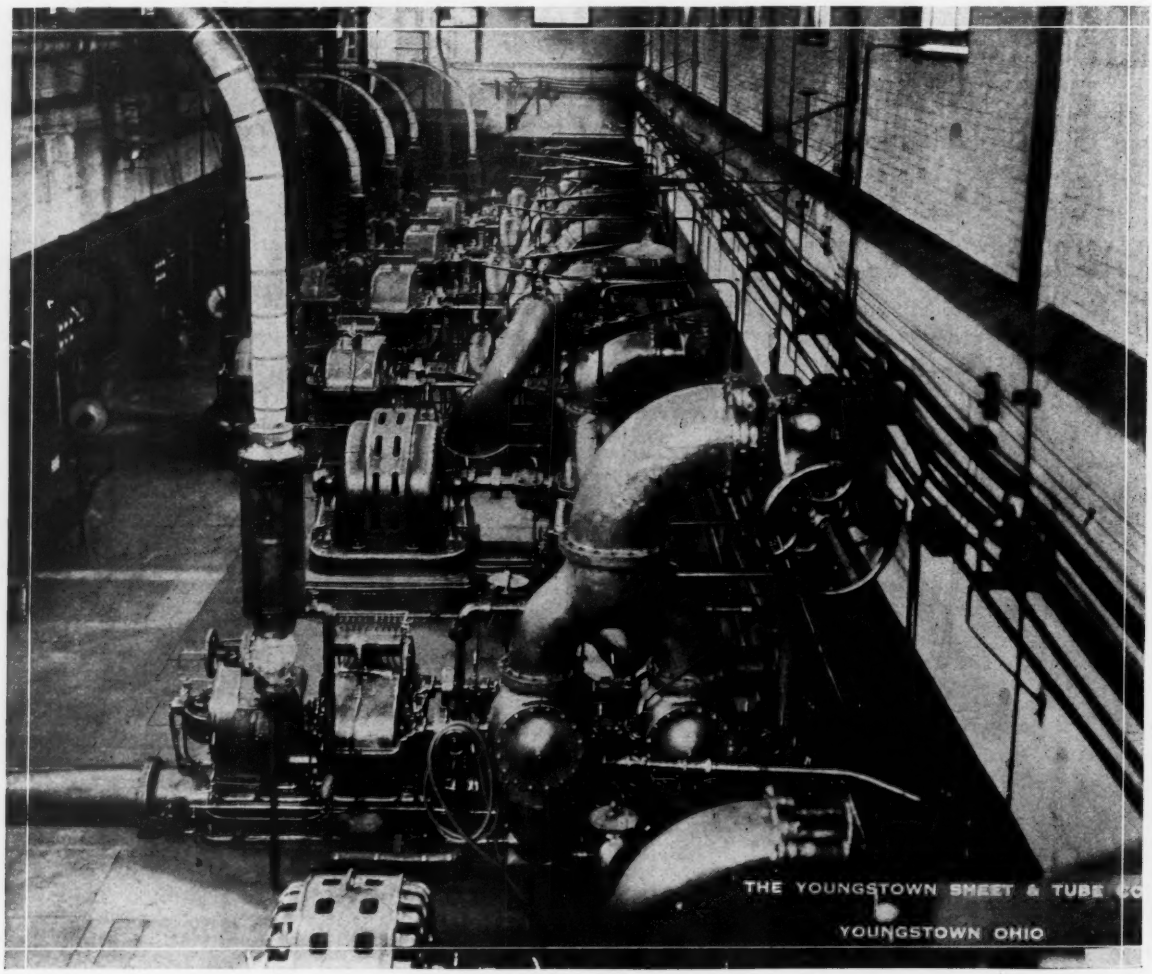


FIG. 1. GENERAL VIEW IN PUMP HOUSE NO. 4

One of these blowers is used to furnish air at a constant pressure of 26 lb. to the Bessemer steel converter. The turbine end is of the Rateau-Smoot type, the speed of which is automatically regulated by the pressure of the air delivered and varies from 1800 to 2200 r.p.m., which is indicated by a Frahm vibrating type tachometer. Steam is supplied at 150 lb. pressure and exhausts into a condenser, the vacuum being maintained as high as the temperature of the cooling water will permit, ranging from 24 in. in summer to 28.5 in. in winter. The turbine is rated at 5000 hp., driving an 8-stage blower which will deliver 40,000 cu. ft. per minute.

The other turbo-blower is of the same type and make, being rated at 40,000 cu. ft. per min., operating at 1800 r.p.m., giving a discharge pressure of 16 lb. average developed in 7 stages, but is automatically governed to give constant volume to the blast furnace which it supplies.

There are 4 blast furnaces, each rated at 500 tons a day, and this blower was installed as an extra, as there are 4 reciprocating blowing tubs, each 48 and 90 by 96 and 96 by 72 in., made by the Wm. Tod Co., of Youngstown. The engines run condensing at 35 r.p.m., normal rating, or 60 maximum speed being rated at 2500 hp., delivering air at an average pressure of 17 lb. The total weight of each of these engines is 1,390,000 lb.

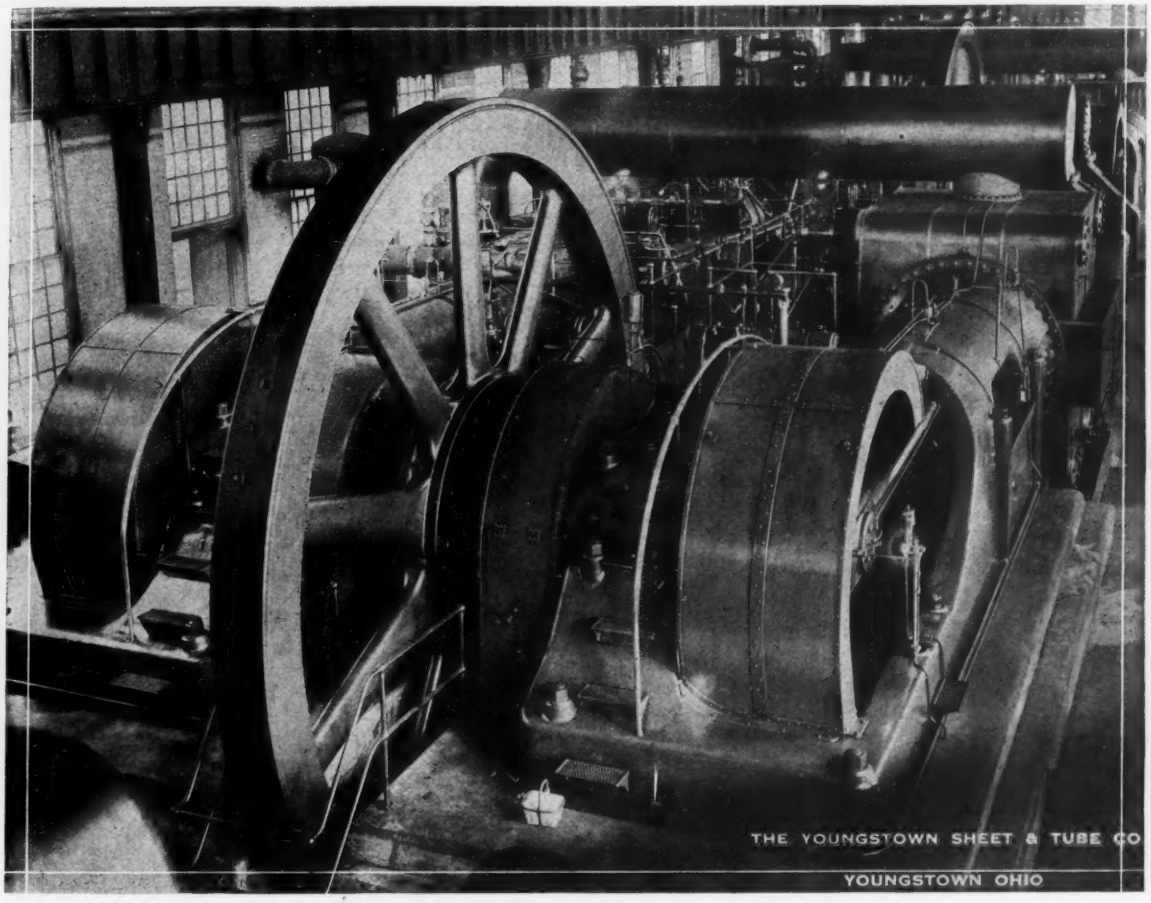


FIG. 3. BLOWING TUB FURNISHING AIR TO THE BLAST FURNACES

In Boiler House No. 3 are 25 500-hp. Stirling boilers, which furnish steam for generating units and pumps at 150 lb. pressure. All these boilers are now being equipped with underfeed stokers, some of which will be Taylor, the others Riley. By 24-hr. tests under actual working conditions, it is found that with the new stoker equipment, the combined furnace and boiler efficiency will average 74 per cent, developing 9 lb. of steam at 150 lb. pressure on 1 lb. of Pittsburgh slack. A forced draft of 4.5 in. of water is used with these stokers.

Coal used in this boiler house is elevated to a storage bunker over the front of the boiler room, from which it is discharged to a traveling scale which, after weighing, delivers to the hoppers of the stokers as required and a record of the total amount of coal burned is thus kept.

Water is delivered through a Venturi meter, which gives a complete record of the weight, so that definite knowledge of the performance of the boilers is always at hand.

Blooming Mill Engine

What is known in the works as No. 2 Blooming Mill Engine has been in operation several months and is reported to be the largest in the world of its kind; the cylinders are 46 and 76 in. in diameter by 60 in. stroke, being arranged in twin tandem compound, running on 150 lb. steam pressure and exhausting into a condenser. The engine is of the Corliss type and made by the Wm. Tod Co., of Youngstown. The engine is of the same type and make, being rated at 40,000 cu. ft. per min., operating at 1800 r.p.m., giving a discharge pressure of 16 lb. average developed in 7 stages, but is automatically governed to give constant volume to the blast furnace which it supplies.

There are 4 blast furnaces, each rated at 500 tons a day, and this blower was installed as an extra, as there are 4 reciprocating blowing tubs, each 48 and 90 by 96 and 96 by 72 in., made by the Wm. Tod Co., of Youngstown. The engines run condensing at 35 r.p.m., normal rating, or 60 maximum speed being rated at 2500 hp., delivering air at an average pressure of 17 lb. The total weight of each of these engines is 1,390,000 lb. delivers to the hoppers of the stokers as required and a German type, employing but 1 lever, and is direct connected to the mill. The total weight is 1,304,000 lb.

In actual practice the reversing time from 60 r.p.m. in one direction to 20 r.p.m. in the other has been found to be 2.2 sec. under working conditions. The cranks are set at 90 deg. on the shaft. The engine is the product of the Mesta Machine Co. of Pittsburgh.

Water Softening and Purifying System

A new We-fu-go water softening and purifying system is now being put into operation, its total capacity is 4,000,000 gal. in 24 hr., and is the product of Wm. B.

Scaife & Sons Co., Pittsburgh, Pa. The water being treated is taken from the discharge from condensers; the temperature varying with weather condition, at times running as high as 140 deg. F.

move sulphates of calcium and magnesium, and at times with iron sulphate (during periods of high turbidity of the Mahoning River) as a coagulant to hasten sedimentation.

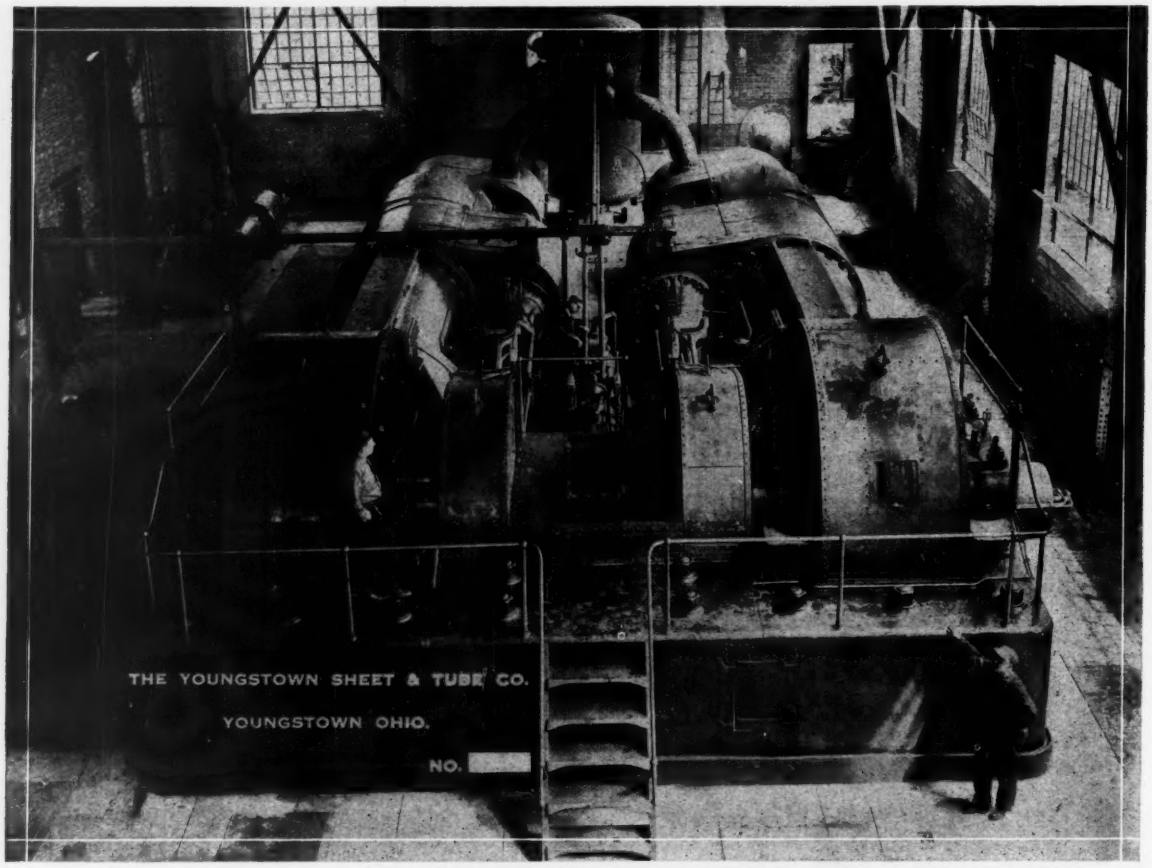


FIG. 4. BLOOMING MILL ENGINE NO. 2

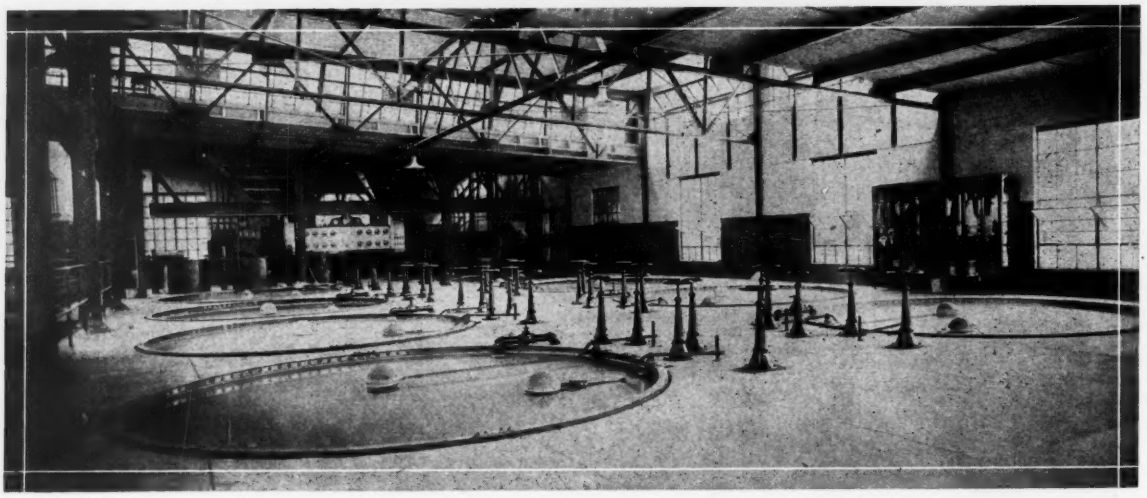


FIG. 6. INTERIOR VIEW OF WATER TREATING PLANT

The process of water softening in this particular case consists of treating the water with lime to remove calcium and magnesium carbonates, with soda ash to re-

All reagents are taken by an electric elevator to a storage room above the reagent mixing tanks. Three hoppers are arranged in the floor, one each for lime,

iron sulphate and soda ash. Below the hoppers is a pair of scales, which run on a track and are provided with a hopper and chute by means of which the different reagents are weighed and dumped into their proper reagent mixing tanks to be dissolved.

This entire purifying system is built up in pairs with cross connections and bypasses, which make it very flexible. The reagent mixing tanks are, therefore, 6 in deliver the dissolved reagents to the tops of the reaction and settling tanks, which are mounted on a masonry foundation outside the building.

There are 8 of these reaction and settling tanks, each with a capacity of 120,000 gal. The agitator consists of a paddle wheel, with vanes at an angles, which rotates about 1 ft. from the bottom of the tank, and is operated by gears on a motor driven line shaft provided

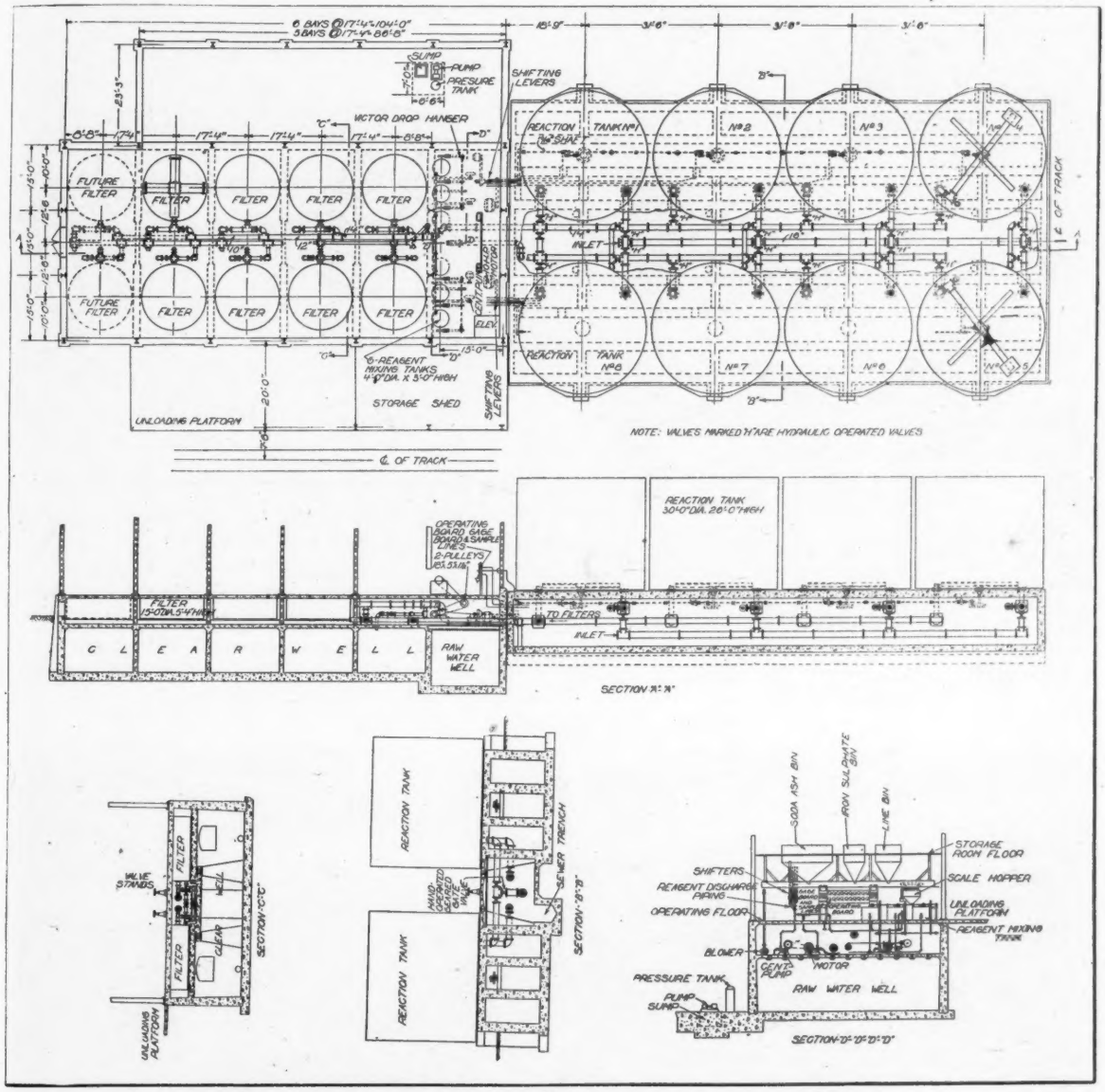


FIG. 5. GENERAL PLAN AND SECTIONS OF THE WATER SOFTENING SYSTEM

number, arranged in sets of 3, each is provided with a stirring device, water and steam connections and an outlet to the reagent pumps. The stirring devices and reagent pumps are driven by 7½-hp. motor through a system of shafting and belts below the floor of the chemical treating room.

The reagent pumps consist of 3 American centrifugal with 2-in. suction and 1½-in. discharge connections, and with a disconnecting pin which is operated by a lever in the treating room.

Reagent solutions are introduced separately, first the lime, after which a sample of the water is taken and tested; then the iron sulphate solution is introduced, followed by the soda ash in this case. During the time the reagents are being introduced, the water is being constantly stirred, and for a period of 15 min. after the

soda ash is introduced; then the water is static for several hours to allow for completion of chemical reaction, coagulation and sedimentation.

The reaction and settling tanks are filled through a 14-in. inlet pipe, which enters at the bottom. This same opening serves also as a sewer connection when the proper valves are operated.

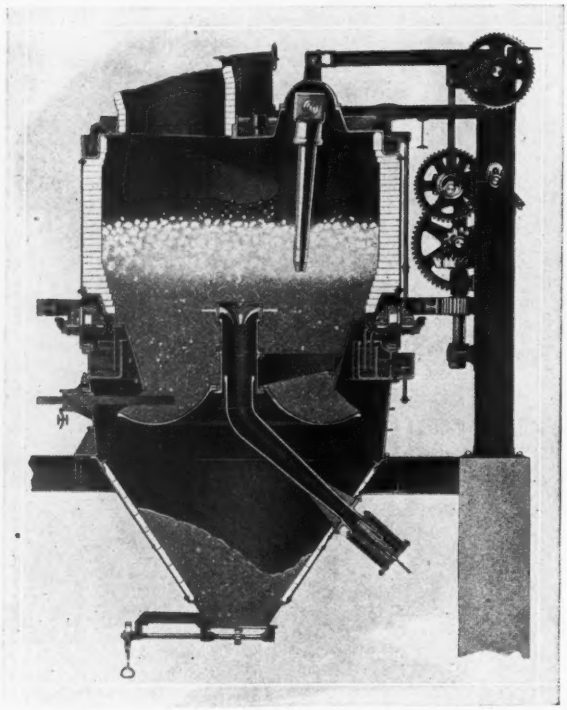


FIG. 8. SECTIONAL VIEW OF SELF CLEANING TYPE HUGHES PRODUCER

Samples are taken through a pipe, opening downward, about 6 ft. from the bottom. The same pipe has a short nipple attached to it extending into the tank a few inches from the bottom, which connects to a mercury column on the valve operating board in the treating room to show the height of water in the tank.

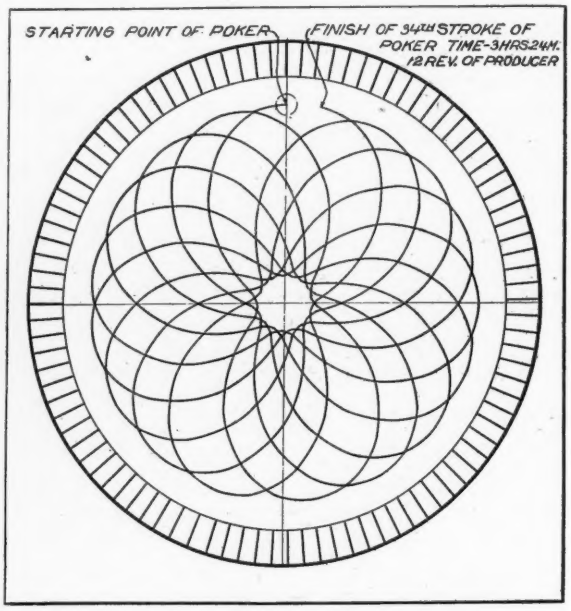


FIG. 9. DIAGRAM SHOWING RELATIVE PATH OF THE POKER IN THE HUGHES PRODUCER

These tanks are also provided with electric high water alarms, which give warning in the treating room when the tank is full.

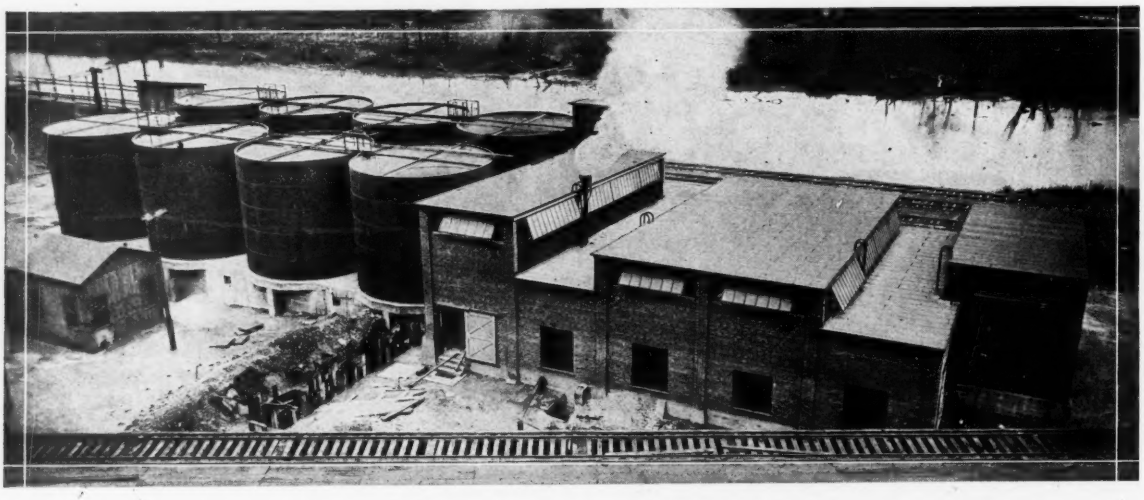


FIG. 7. EXTERIOR VIEW OF WATER TREATING PLANT

The outlet is through a 14-in. pipe, which is provided with a swinging joint and float, thus all water drawn from the tanks for the filters is taken from near the surface, where it is clear of precipitates.

All the water inlet and outlet valves to these tanks are operated by hydraulic pressure and controlled from the marble board in the treating room. This board contains, besides the operating valves, a mercury column

for each precipitating tank, faucets for taking samples, a Bristol recording gage giving the pressure on the water line to the heaters and a clock for convenience of operators.

The filtering equipment is located under cover adjoining the treating room and consists of 8 quartz filters working on the down filtration process. Each filter is designed to care for 20,834 gal. per hour.

Water comes direct from the reaction and settling tanks by gravity to the filters through 14-in. inlet pipes, which discharge into cross troughs to prevent displacement of the quartz. Floats control the flow to filters.

For each filter the following valves are provided: inlet, outlet, wash, rewash and sewer.

Cleaning the filters is done by reversing the flow of the water through the quartz. A Connersville positive air blower is used to supply air to stir the quartz bed and to supplement the action of the water during the washing process.

revolving with it, carrying a blower supplying steam and air, and a water-cooled top plate with a depending vibrating water-cooled poker.

In operation the incandescent zone of fuel rests upon a bed of ashes extending from the ash pan to a point ranging from 6 to 10 in. above the blower hood. The incandescent zone is from 10 to 30 in. deep, according to the demand for gas and the consequent condition of the fire. Over this, the green coal is spread to a depth of from 4 to 8 in.

The water-cooled poker, supported by the stationary top of the producer and extending through the green coal zone and partly into the incandescent zone, moves in an arc between the center of the producer and a point within a few inches of the shell lining. As the poker swings backward and forward, the producer shell slowly revolves so that the path in the fuel taken by the poker forms a series of ellipses, as shown by the accompanying diagram.

DE LAVAL PUMPS IN NO. 4 PUMP HOUSE

Pump Number	Size—Inches	Number of Stages	Head in feet	Capacity Gal. per Min.	Speed—R.P.M.	Kind of Drive	Description of Driving Element	Service to which water is put
1	30	1	36	13,600	1100	Turb	De Laval 11,000 r.p.m. through 10 to 1 reduction gears.	Cooling water for blast furnace condenser.
2	20	2	120	8400	600	Turb.	350-hp. De Laval 9000 r.p.m.	Deliver to 55-lb. service line.
3	20	2	120	8400	600	Turb.		
4	20	2	120	8400	600	Turb.		
5	20	2	120	12,600	750	Turb.	De Laval 525 hp.	Deliver to 55-lb. service line.
6	20	2	120	11,000	750	Motor	Crocker-Wheeler 500-hp. Sync. 6600 v., 3 ph., 25 c.	Deliver to 55-lb. service line.
7	16	1	65	11,200	900	Turb.	De Laval	Circulating condensing water for sheet mill, puddle mill and converting mill blowing room condensers, Nos. 2 & 3 power houses and gas furnace blowing engine condensers.
8	16	1	50	7,000	720	Motor	Westinghouse 150-hp., a.c., ind., 3 ph., 25 c., 220 v.	
9	16	1	50	7,000	720	Motor		
10	20	1	60	14,000		Motor	250-hp., G.E., ind. 3 ph., 25 c., 220 v.	
11	8	1	110	1200	1440	Motor	50-hp. Westinghouse Ind., 3 ph., 25 c., 220 v.	Circulation water for wearing plates on blast furnaces.

In the pump pit are 3 Wilson-Snyder centrifugal pumps. One is driven by a G. E. 100-hp. motor, and is used to draw the water from the discharge of the condensing water and deliver it to the precipitating tanks. The other 2 units are alike, each being driven by a 110-hp. Kerr turbine, and deliver to the line leading to the feed water heaters.

Automatic Gas Producers

Mention has been made of the gas producers used in this plant. To furnish gas for the open hearths, there are arranged in one battery 18 Hughes rotary gas producers, which are successfully operated with bituminous coal. This type of producer consists of a revolving brick-lined shell with water seals at the top and bottom enclosing the coal to be gasified, an ash support attached to and

The combined action of these movements has the effect of preventing inequalities in the fuel bed, which might otherwise be caused if the feeding of the coal became uneven. Blow holes, which tend to develop in the incandescent zone, are eliminated. The result is the uniform production of rich gas. The capacity of each of these producers under normal working conditions is 2000 lb. of coal per hour.

In addition to the battery furnishing gas to the open hearths, there is another battery of 4 Morgan producers which supplies gas to 6 large 4-hole soaking pits. These producers also use bituminous coal and are completely mechanical; that is, the coal is fed to the producer, the fire is kept in condition and the ashes removed with a minimum of labor. This results in a uniform quality of gas and large capacity.

Weir Considerations

IMPORTANCE OF HAVING CORRECT CONSTRUCTION; CAUTIONS TO BE OBSERVED IN TAKING MEASUREMENTS. BY ALBERT H. ISRAEL

FROM time to time articles have appeared on the subject of weirs. A complete explanation of the theory or else the deduction of a formula has generally been given; but the simple rules which must be observed in such measurements, if the formulas derived are to be used at all, have been omitted. It is therefore my purpose to set before the reader only those practical points which ought to be observed if a set of formulas are to give true results.

All the formulas which were set forth by the famous hydraulic engineers concerning weirs were of 2 general classes, the one applying only to weirs in which perfect contraction of the stream takes place, while the other applies only to those without end contractions. In either case, the weir must be properly constructed and the measurements must be taken in a correct manner.

CONSTRUCTION

THE SIZE of the weir to be used depends upon the amount of water to be measured in a given time. Merrimann states: "The head of water upon the crest of a weir is usually much less than the breadth of the crest.

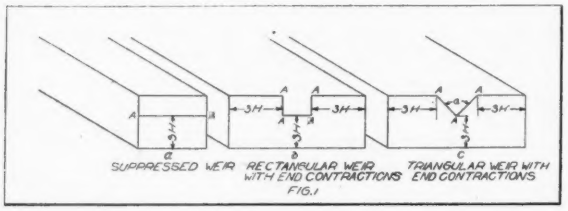


FIG. 1. COMMON TYPES OF WEIRS

The value of the head should not be less than 0.1 ft. and should not exceed 4.5 ft. in order to keep within the range of the experiments on the standard weir. The least value of the breadth in practice is about 0.5 ft., and it does not often exceed 20 ft." From this we may see that if the approximated flow of the liquid to be measured is not sufficient to give us values which lie within those given, that the weir ought not to be used, and the orifice would be more suitable and more accurate.

If the velocity of approach (explained later) of the water is to be neglected, then the weir opening area ought to be small compared with the cross-sectional area (perpendicular to the direction of flow) of the reservoir or channel of approach.

The weir proper must be perpendicular to the direction of flow, or in more accurate language, all edges comprising the weir must lie in one plane, which is parallel to a plumb line. If no special formulas are to be developed, then the crest of the suppressed and full contracted weir (shown in Fig. 1, a and b), must be level, while the ends are perpendicular thereto or parallel to a plumb line. In the case of the triangular weir the bisector of the angle should be parallel to a plumb line.

To obtain perfect contraction, the dimensions given in Fig. 1 should be followed; each one being the minimum to be used. In each case, H represents the head above the crest. In the case of the triangular weir, one is always on the safe side if the distances given to the sides are used, but they may be laid off on a level line which is 4H above the bottom. The edges marked A-A should be straight, and sharp, theoretically; but if they were to come to a knife edge, any floating material happening to strike an edge would injure it. For this reason the edges are made as is shown in Fig. 2. The bevel angle may be less than 30 deg., but should in no case be greater. The angle a may have any value if the proper formula is used. In most instances, however, the angle is 90 deg.

For small weirs, such as those used in most power plants, metal is best. The edges should be made as shown in Fig. 2. No bevel is necessary if the metal is 1/32 in. or less in thickness, but the edges should all be square. The reservoir or channel of approach may be made of metal, concrete or wood, as may be desired.

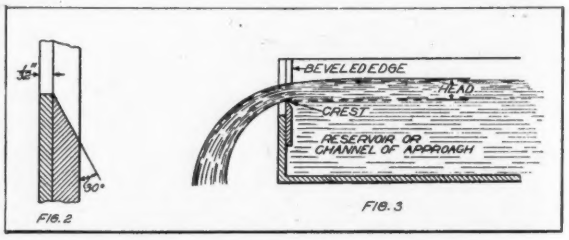


FIG. 2. ENLARGED EDGE OF WEIR IN SECTION

FIG. 3. SECTION SHOWING DECREASE IN HEAD AT CREST

The length of the reservoir should be such that the water will reach the weir in a quiet state. The minimum length is from 8 to 10 ft.

If the water is in an unquiet state one or more baffle boards or planks should be placed across the channel at right angles to the direction of flow, and at varying depths from the surface, to reduce the velocity of the water as it approaches the weir. Often the water may be quieted by simply changing the arrangement of the inlet to the reservoir.

Greatest care should be taken in obtaining the head, H, since this is the most important factor in weir measurements. Whether the hook gage or the float is used, they should always be located in a small reservoir offset from the large one; and because the water is almost motionless therein, it has received the name still well. The least diameter of the well should not be less than 6 in. It must be connected with the main reservoir as is shown in Fig. 5. The pipe connection and the perforated pipe should not be less than one inch standard pipe. Holes should be drilled along the pipe and at various points on the circumference. The distance B in Fig. 5 ought not be less than one foot nor greater

than 6 or 8 ft., else it will take too long to transmit a change in head in the reservoir to the still well, unless, of course, the flow is nearly constant, in which case, the exact distance is immaterial. Water flowing from a weir appears as shown in Fig. 3. It may be seen that if the head were measured too close to the weir an incorrect quantity would be obtained. For this reason the perforated pipe should be placed 3 to 5 ft. back of the crest of the weir in the ordinary sizes.

The inlet to the reservoir is placed just back of the baffles, if there are any, as is shown in Fig. 4. The specific construction of the inlet will not be discussed here, but it may be said that that construction is best which prevents the water from becoming too turbulent in the reservoir.

Measurement

Assuming now that all the constructional provisions have been complied with, we will look into the factors which enter into the actual measurement of the water passing over the weir.

When the weir is in use we must take proper care of the edges, by keeping them smooth and free from obstruction or slime, which often accompanies the flow of water and other liquids.

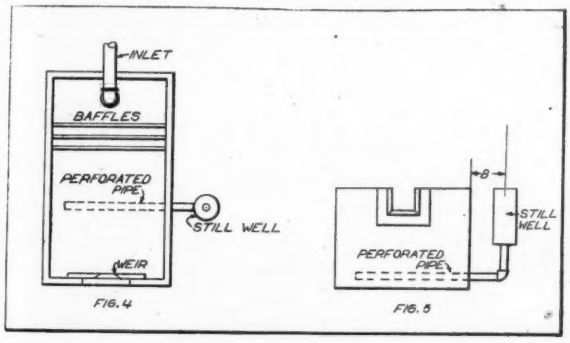


FIG. 4. PLAN OF WEIR BOX SHOWING BAFFLES AND STILL WELL

FIG. 5. SEPARATE STILL WELL FOR GAGE

The head is the most important reading to be taken and it is also the one into which most inaccuracies enter. It is therefore necessary to be especially careful in obtaining this reading. The hook gage ought to be used in preference to the float gage whenever a result is to be obtained requiring any precision. Those taking the readings should also see that the correct zero reading has been obtained, because the level of the water in the reservoir may be above the crest of the weir without causing any flow to take place, due to molecular attraction or cohesion.

The velocity of approach is the rate at which the water is flowing through the channel or reservoir toward the weir. It is generally stated in feet per second. To obtain this quantity, we must first find the approximate flow in cubic feet per second, either from the simple weir formula, which neglects the velocity of approach, or from other data at hand. The equivalent head is used in formulas in place of the velocity of approach. It is found in the following manner.

Let q = approximated cubic feet flowing per second.
w = width of channel or reservoir in feet.
d = distance from crest of weir to bottom in feet.
H = head or height of level above crest in feet.
A = cross-sectional area of channel perpendicular to flow in square feet.
h = head which is equivalent to the velocity of approach in feet.
v = velocity of approach in feet per second.
g = acceleration due to gravity = 32.16 ft. per sec. per sec.

We know that

$$q = Av \text{ and } A = w(d + H)$$

therefore

$$v = \frac{q}{A}$$

then knowing v, we may substitute in the equation for h, thus—

$$\frac{v^2}{2g} = h.$$

This equivalent head of the velocity of approach has the same effect as increasing the total head on the weir, and is generally taken into account as a separate quantity in formulas given by Hamilton, Smith or Francis. It should be remembered that if any degree of accuracy is required, this velocity of approach must be taken into consideration.

To be accurate, we should also take temperature into consideration, since the density of liquids varies with the temperature and since most results are wanted in pounds flowing per unit time. Five or 10 deg. make no appreciable difference in the density, and in such cases the temperature may be taken as that of the surrounding air.

All the foregoing will be of little value, if a formula is used which does not apply to the case in hand. It is therefore important that we use a formula which may be applied to the type of weir used, and having found the correct equation, we should be careful to apply the right coefficient. Only in a few cases of small weirs are we exempt from this duty, since only the small weirs are capable of calibration at a small expense.

Inspecting Corliss Valve Chambers

By F. W. Salmon

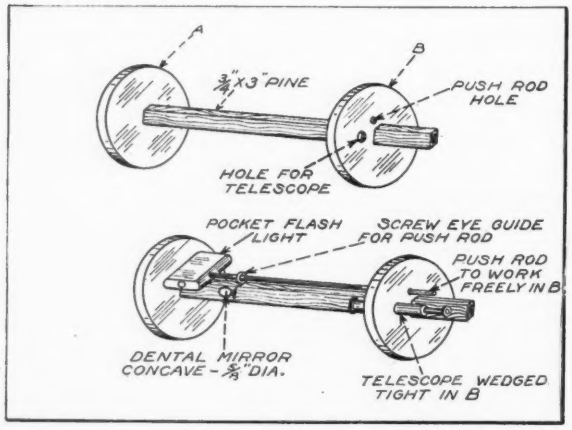
How many readers of this magazine realize the necessity of tight valves, valves that do not leak? How many know what the leakage of their valves costs them (or rather their employers) a year? Some people think that when a valve has run for a few days it will be sure to be tight; from some years of experience, I would not be sure from the simple fact that it had run a few weeks or days.

I favor inspecting the valves and the ports, and testing them, too. Inspect them to see that they are well made of good material in the first place, and frequently thereafter to be sure that they do not cut or wear unevenly; of course, every licensed engineer and every engineer who has "learnt" his trade, knows how to test

them for tightness with steam or air pressure, so we will pass by the testing and take up the inspecting.

Now, the valve is not a very difficult thing to inspect. The surfaces can be tried with straight edges for light passing or with marking of red-lead-and-oil or black-lead-and-oil, and for being a truly round surface with a ring about an inch thick bored to the exact size, or the valve can be mounted between dead-centers on a milling machine platen and slowly revolved on the dead centers with a dial micrometer like Starrett's No. 196 held in a surface gage stand against the periphery, any movement of the hand will show eccentricity or irregularity of surface, which of course should be corrected.

A small pocket microscope about 1¼ in. diameter is also a nice thing to use for examining the surface to see if it has been properly ground below the ragged surface resulting from the cutting tools and with a grinding wheel of suitable grade of fineness, for fine grinding costs more and is worth more than grinding with a coarse wheel; and again, if the valve is annealed after machining, before grinding, it is not so likely to warp when heated by the steam and therefore not so likely to leak or cut, and the microscope will show in almost all cases whether it has been so annealed.



HOME-MADE INSPECTOR'S INSTRUMENT

Now, the Corliss valve chamber is more likely to be rough or defective than the valve and so should be inspected with more care; but, owing to its small size, it is often not inspected at all, yet with the simple and inexpensive device shown in the accompanying illustration, this is easily and conveniently done. I will describe the instrument as I like it made for the ordinary Corliss engine; but the reader can, of course, vary from this to suit the size and location of the engine and to use the apparatus at hand or easily obtainable.

On a piece of wood about 3 by ¾-in. and a little longer than the length of the valve, secure a round piece of wood, A, that is a neat sliding fit in the valve chamber and about ½ in. thick, then secure on B, similar to A, about 2 in. from the end of the center-piece, and fasten on the pocket flash-light with a light wooden rod about ½ in. in diameter for pressing the button of the flash-light as shown, and the dental concave mirror and the telescope as shown.

Most engineers have a pocket flash-light, while the dental concave mirrors with tangs but without handles cost about 25 cents each at dental supply houses, and the tangs, being brass wire, can be bent so that the mirror will stand at about 45 deg. with the valve-seat surface and at 1½ or 2 in. from it so as to focus well.

The telescope is easily obtainable from the firms who supply high schools and colleges, is about 7 or 8 in. long and has an objective about ¾-in. diameter, is fitted with a cross-hair, and can be focused on objects from about 2 ft. to 10 or 12 ft. from it and will magnify about 6 times, and costs 6 or 7 dollars commonly. Adjust the telescope in the hole in B so as to get a good clear view of the dental mirror and adjust the dental mirror, all outside the valve-chamber and in good daylight.

Take the complete instrument to the cylinder, put a photographer's focusing cloth over your head and the board B, or something dark-colored to serve that purpose, put the A end in the Corliss valve chamber, turn on the light by means of the push-rod and inspect every square inch of the valve chamber through the telescope, by sliding the instrument back and forth through the chamber and revolving it also. If there are any defects, it will be all your fault if you don't find them and know all about them; little grains of sand will look as big as pails, and little cracks from shrinkage, etc., will show up many times their natural size, but not much out of their importance in the matter of steam leakage and waste.

Cleaning Boiler Tubes

DIFFICULTIES ENCOUNTERED AND PRECAUTIONS TO BE OBSERVED. BY J. C. HAWKINS

WHILE in charge of a power plant using a very bad feed water we had a great deal of trouble with scale in the tubes of our Stirling boilers. The tubes of these boilers are small, long and crooked, and although nearly vertical, the rear bank which the water enters first is liable to become plugged up with scale if the water is bad. The boilers were washed out every 2 weeks, which was done by sticking the hose nozzle in the upper end of every tube. Not infrequently, a tube would be found plugged up solid with loose scale, or would become so in washing out. Sometimes it was a difficult matter to clean it out.

To get a hole through the tube we made a jointed rod like a surveyor's chain having links about 18 in. long, as shown in Fig. 1. This jointed rod was 11 ft. long, and made of 9/16-in. square steel stock. The links were welded and each was short enough to pass around the bends in the tube, being used as a chisel usually from the bottom end, and driven by a small sledge. This tool will stand a great deal of hard usage and as the sections are short, it can be used in the mud drum with a sledge.

In drilling out scale with a turbine cleaner, sometimes the tube was so nearly closed that the loose scale coming off could not get through. This would have to be punched out with a jointed rod. In drilling the tubes in this type of boiler it is usually necessary to get into the steam drum, although there is a device on the market for feeding the hose down from the outside of the drum. Better and faster work can be done, however, from the

inside; but it is usually hot in the drums. We overcame this trouble in the following manner. Only one steam drum was opened at a time, and the mud drum plate taken out.

In these boilers the mud drum was inside the brickwork with a small space for expansion between the head and wall, the outside door in the wall preventing air leaking in around the drum. With one steam drum open, the mud drum plate out, the outside door closed, the damper partly open, and ash pit doors closed, cool air would be drawn into the steam drum, down through the tubes, out through the mud drum manhole, and around the space to the combustion chamber. This made it comfortable to work in the steam drum. In a boiler in which the mud drum comes flush with the brick work, a light sheet iron pipe can be made which, when in place, will connect the end of the mud drum with a side cleaning door, as shown in Fig. 2.

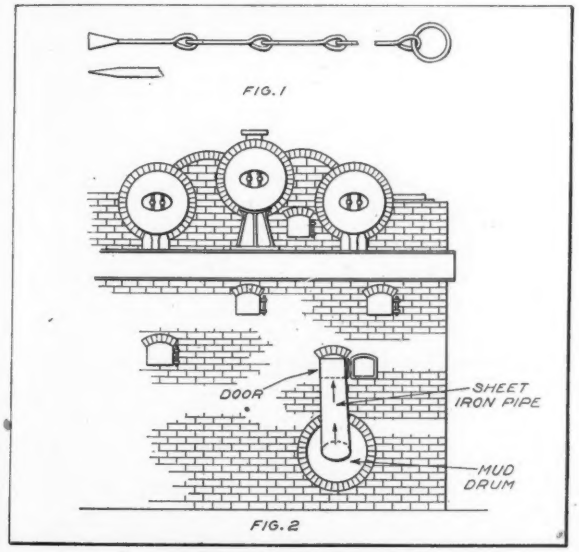


FIG. 1. JOINTED ROD FOR REMOVING SCALE
FIG. 2. SHEET-IRON PIPE CONNECTING MUD DRUM MANHOLE TO CLEAN OUT DOOR

When drilling from inside the drum, 2 men are required—one to operate the drill, and the other to operate the water valve. This difficulty was overcome by placing a butterfly valve on the end of the water line, whose stem carried a lever, one end of which was weighted, and a rope was connected to the other end, which passed inside the drum. See Fig. 3. A short piece of board tapered at one end to go into a tube and having a V notch cut in the other end, was used to hold the rope when the valve was open. The valve was opened by pulling the rope and closed by the weight. The man in the drum could stop and start the water whenever he wished. A better way would be to have a valve piston operated by a pilot valve to which the rope is connected. This would not turn the water on as suddenly as the butterfly valve did. In order to accomplish anything where the scale is thick and hard, a good water pressure must be used. We used 170 lb. The pump was controlled by a pump governor with a relief valve on the discharge line. This drives the turbine cleaner at a high speed, and it must be kept moving to prevent cutting a hole through the tube.

One day the boiler cleaner had a tired feeling and, after getting started on a bad tube, took a nap, letting the turbine run. When the boiler was filled up we found one tube with a hole in it about 1 by 2 in., and it cost only $9.60 to put in a new one. Another source of trouble at the high pressure we carried was to get the hose coupling to hold. The coupling has to be short to pass through the bends in the tubes, and when a 2-in. hose is used in a 3½-in. tube, there is no room for a clamp on the outside. A piece of 1½-in. pipe was threaded full length, and one end tapered. Then it was heated to a black heat and screwed into the hose. Heating the pipe caused the rubber to stick to it. Then the outside was wrapped closely with No. 12 galvanized wire, which was wound tight with a device shown in Fig. 4. In this device the clamps were used to put tension on the wire and if screwed down tight enough the wire could be broken. A coupling put in in this manner will stay as long as the hose lasts. The wrapping wire was wound over the end of the armor wire a few

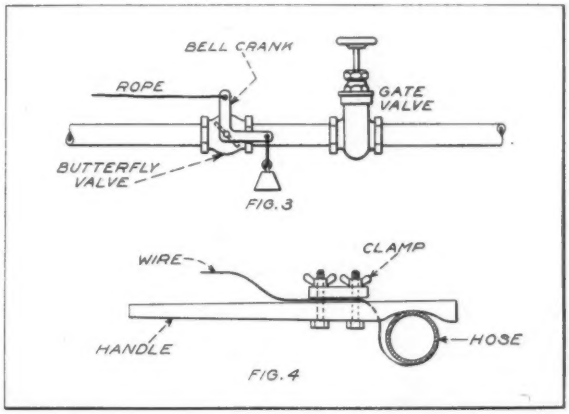


FIG. 3. VALVE IN WATER LINE TO CLEANER
FIG. 4. WIRE WINDING DEVICE

turns, which prevented it from catching in the tube, and also from pushing back from the end of the hose.

In drilling with water, the blowoff must be left open to prevent the water from running down around the setting or over the floor; but unless it is protected it will soon fill up with scale. This was prevented by making a strainer of a 2½-in. pipe flange with a 14-in. piece of pipe screwed into it open on the end with several small holes drilled in the side. This was set over the blowoff opening and allowed the water to pass, but effectually stopped the scale.

When a man is working inside a boiler, extreme care must be taken by all others in the plant to prevent steam or hot water being turned into the dead boiler.

Although the foregoing is applied principally to the Stirling boiler, it may be applied equally well to any boiler, but in the B. & W., and Heine type it is not necessary to get into the drum to clean the tubes. There are 1 or 2 turbine cleaners on the market which are driven by compressed air; in some cases, these give better satisfaction than the water-driven type. With this cleaner, it is necessary to run a small stream of water into the tube being cleaned to wash the scale out

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Voltage Regulation of the Alternator

DISTRIBUTION OF FLUX; THEORY OF REGULATION; METHODS OF CALCULATING REGULATION

AN alternator, driven at a constant speed and having a constant field excitation, gives a certain terminal voltage when its current output is zero, which falls off in value with an increase of load, or current output; or, if the machine is adjusted to give a certain terminal voltage at full load, its terminal voltage generally rises with a decrease of load. The increase of voltage from full load to no load, expressed in per cent of normal full load voltage, field excitation and speed being constant, is called the voltage regulation of the machine.

Voltage regulation of an alternator varies greatly with the power factor of the receiving circuit. A machine may have on noninductive load, a full-load voltage of 1100 and a no-load voltage of 1188, which, with an inductive load of 0.80 power factor, would rise to 1386 upon opening the main switch. When an alternator delivers current to a receiving circuit like a condenser, in which the current is ahead of the electromotive force in phase, the regulation of the alternator is better than when the receiving circuit is noninductive. Thus, an alternator may have a regulation of zero per cent when delivering current to a condenser circuit having a power factor of 0.97 and a regulation of minus 14 per cent when it delivers current to a condenser circuit having a power factor equal to 0.80. A zero per cent regulation means no rise of terminal voltage from full load to zero load, and a negative regulation means a decrease of terminal voltage when the current output is reduced from full load to zero load.

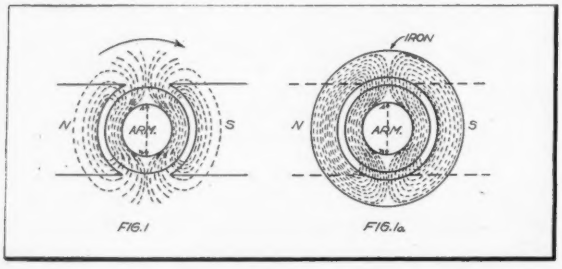


FIG. 1 & 1A. ACTUAL AND ASSUMED FLUX DISTRIBUTION AT UNITY POWER FACTOR

THEORY OF VOLTAGE REGULATION

RESISTANCE of the armature windings and the magnetizing action of the armature current or currents, are the causes of decreased terminal voltage with increase of current output. In discussing the effect of magnetizing action of the armature current or currents, it is convenient to think of the field windings as producing a certain constant flux, F, and of the armature current or currents producing an additional flux, F^1, and for brevity we may call F the field flux and F^1 the armature flux, although both F and F^1 pass through the armature.

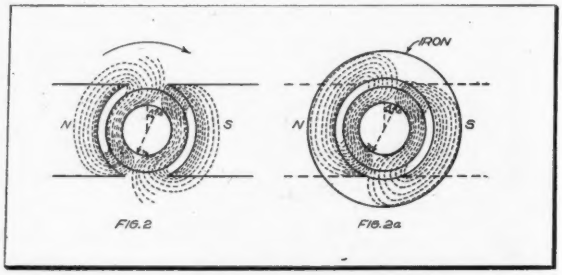


FIG. 2 & 2A. ACTUAL AND ASSUMED FLUX DISTRIBUTION AT LAGGING POWER FACTOR

Field flux, F, may be thought of as producing a certain total induced electromotive force, a portion of which is lost in balancing the electromotive force induced by the armature flux F^1, another portion lost in overcoming the resistance of the armature winding, while the remainder appears as the terminal voltage of the machine. In order to calculate the voltage regulation of an alternator it is, therefore, necessary to consider the value and phase of the electromotive force induced in the armature windings by the flux F.

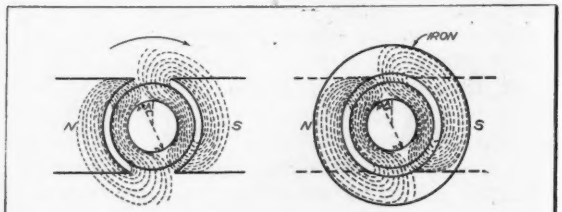


FIG. 3 & 3A. ACTUAL AND ASSUMED FLUX DISTRIBUTION; LEADING CURRENT

In the polyphase alternator with a balanced load, the armature flux F^1 is constant in value (for given loads)

and fixed in space, and electromotive forces are induced in the moving armature conductors as they cut this flux. In the single-phase alternator, on the other hand, the armature flux F^1 is neither constant in value nor fixed in space and the electromotive forces produced in the armature conductors by F^1 are quite complicated. For this reason the following discussion applies primarily to the polyphase alternator with a balanced load and for the sake of simplicity is restricted to a 2-pole machine.

When a polyphase alternator delivers current to a balanced noninductive receiving circuit, the axis of the armature magnetizing action (axis of F) is at right angles to the axis of the field, as shown in Fig. 1, in which N and S represent the magnetic poles on the armature core due to the armature magnetizing action.

The dotted lines in Fig. 1 represent the actual distribution of the armature flux F^1 and those in Fig. 1a represent the distribution of F^1, on the assumption that the iron of the pole pieces completely and uniformly surrounds the armature.

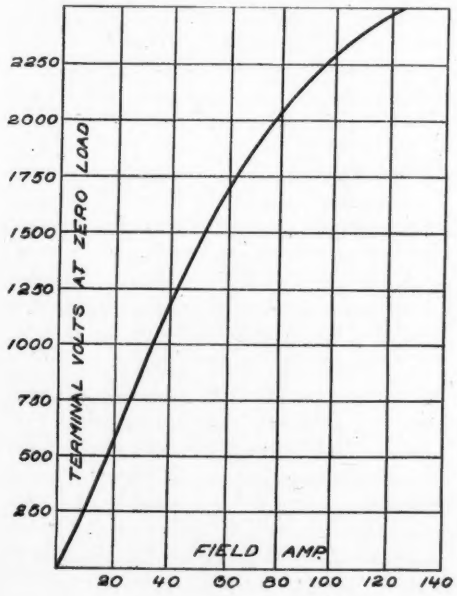


FIG. 4. SATURATION CURVE

When a polyphase alternator delivers current to balanced inductive receiving circuits, the axis of armature-magnetizing action (axis of F^1) is shifted forward through the angle A as shown in Figs. 2 and 2a, where A is the phase angle between voltage and current in each receiving circuit and when the currents in the receiving circuit lead the electromotive forces in phase by the angle A, the axis of F^1 is shifted backward, as shown in Figs. 3 and 3a.

From the foregoing, several important things are at once evident. (1) The armature flux F^1 is, to a certain extent, opposed to the field flux F in Fig. 2a. (2) The armature flux F^1 is, to a certain extent, in the direction of the field flux F in Fig. 3, and (3) the armature flux F^1 neither helps nor opposes the field flux F in Fig. 1.

(4) The distribution of F^1 is far from being harmonic, which results in the electromotive forces induced by F^1 in the moving armature conductors not being harmonic. In order to formulate a simple method for calculating the voltage regulation of an alternator, a method must be used which is based on the assumption that F^1 is harmonically distributed as shown in Figs. 1a, 2a and 3a, in which the field magnet is assumed to have no polar projections but to surround the armature uniformly on all sides as indicated.

(5) From Fig. 1 it is evident that the electromotive force induced in each armature winding by the flux F^1 is 90 deg. behind the electromotive force induced by the field flux F, so that the portion of the total induced electromotive force (due to F) which is used to overcome the electromotive force produced by F^1 is 90 deg. ahead of the total induced electromotive force, or 90 deg. ahead of the current in the given armature winding. A careful consideration of Figs. 2a and 3a makes it evident that in every case, the portion of the total induced electromotive force which is lost in overcoming the electromotive force produced by F^1 is 90 deg. ahead of the current in phase.

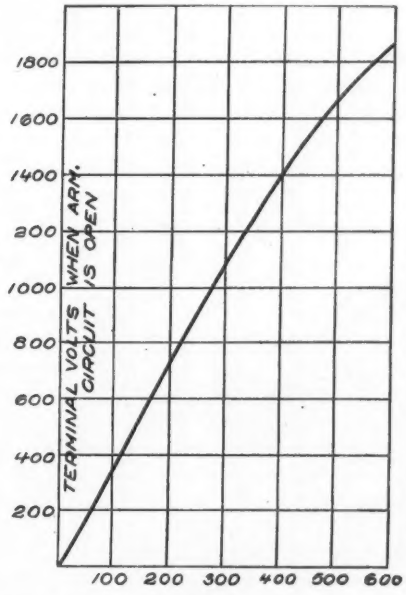


FIG. 5. SYNCHRONOUS REACTANCE CURVE

This lost electromotive force is proportional to the armature current, I, so that it may be expressed as XI, where X is a reactance, as in an inductance reactance, and is called the synchronous reactance of the armature.

Calculation of Regulation

Purchasers of electrical machinery demand that the manufacturers make a specified guarantee as to the voltage regulation of alternators, in view of which it is always necessary for the manufacturer to determine the regulation by test. With small generators, this test can easily be made by driving the machine, adjusting its field excitation to give normal voltage at full load and noting the rise in voltage when the load is removed. In the case of large machines, this method can hardly be used and it is, therefore, necessary to calculate the regulation in terms of easily obtained data. The data used for this purpose are included in what are called

the saturation curve and synchronous reactance curve.

The saturation curve is a curve obtained by plotting the values of the field current against the corresponding observed values of the terminal voltage of the machine at zero load. The synchronous reactance curve is determined as follows: The armature is short-circuited through an ammeter, the machine is driven at normal speed, the field excitation is adjusted until full load current (or any fraction thereof) flows through the ammeter and the ammeter reading is taken. The short circuit is then removed and with unchanged speed and field excitation, the terminal voltage is measured. A curve, using ammeter readings as horizontal values and the corresponding open-circuit voltages as vertical values, is then plotted as shown in Fig. 5. Fig. 4 illustrates a saturation curve which, together with the synchronous reactance curve, was taken from a 2000-kw. delta-connected 3-phase alternator.

The electromotive force method of calculating regulation may be best explained by giving numerical examples. Let it be required to calculate the voltage regulation of a 2000-v., 2000-kw., 3-phase alternator (a) for

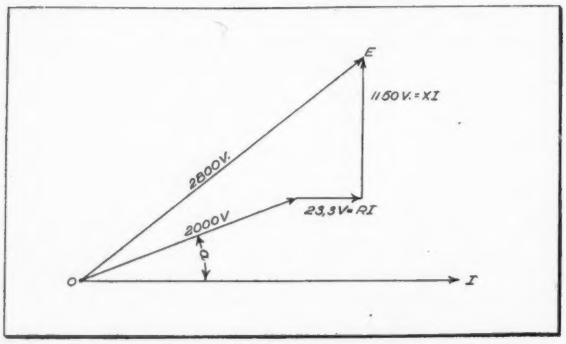


FIG. 6. GRAPHICAL SOLUTION OF ZERO LOAD VOLTAGE

receiving circuits of unity power factor and (b) for receiving circuits of 0.85 power factor, the resistance of one of the armature windings being 0.07 ohm.

(a) For unity power factor: The full load current in one armature winding is 333 amp., so that the resistance drop in the armature at full load is 23.3 v. This drop is in phase with the current and, therefore, in phase with the terminal voltage, since the power factor is assumed to be unity; so that the sum of the resistance drop and terminal voltage is 2023.3 v. From the reactance curve, we find that 1150 v. corresponds to 333 amp., hence the total induced electromotive force is equal to the square root of $[(2023.3)^2 + (1150)^2]$ or 2327 v., which is the value to which the terminal voltage would rise if the load was reduced to zero. The regulation of the machine for unity power factor is, therefore, $(2327 - 2000) \div 2000 = 0.163$, or 16.3 per cent.

(b) For a power factor equal to 0.85: In Fig. 6, choose the vector OI as the reference axis, lay off the full-load terminal voltage of 2000 v. in its proper phase relation to I (Cos. a = 0.85), and lay off resistance drop, RI, 23.3 v., and reactance drop XI, 1150 v., as shown; the line OE will then represent the total induced electromotive force, and it is the value to which the terminal voltage of the machine would rise if the current output was reduced to zero. The value of the zero-load voltage (corresponding to 2000 v. terminal voltage at full load and 0.85 power factor) is thus found to be 2800 v., so that the regulation is $(2800 - 2000) \div 2000 = 0.40$, or 40 per cent.

The magnetomotive force method will now be illustrated as was the electromotive force method.

(a) Unity power factor. When the alternator delivers full-load current of 333 amp. from each of its armature windings to noninductive receiving circuits, the 2 components of the total induced voltage parallel to and at right angles to the current are 2023.3 v. and 1150 v., as explained under the electromotive force method. From the saturation curve we find that a field current of 84 amp. is required to give 2023 v. total induced electromotive force; and a field current of 42 amp. is required to give a total induced electromotive force of 1150 v. To give these 2 quadrature electromotive forces simultaneously a field current equal to 94 amp. [= square root of $(84^2 + 42^2)$] would be required; and according to the saturation curve, this field current of 94 amp. would give a total induced electromotive force of 2200 v., which is the value to which the terminal voltage of the machine would rise at zero load. The regulation of the machine is therefore $(2200 - 2000) \div 2000 = 0.10$, or 10 per cent.

(b) For power factor equal to 0.85. From Fig. 6, the 2 components of the total induced electromotive force, parallel and perpendicular to the current, are 1723.3 v. and 2207 v. respectively. The field currents required to produce total induced voltages of 1723.3 and 2207 are found from the saturation curve to be 68 amp. and 94 amp. respectively, and to give these 2 quadrature electromotive forces simultaneously would require 116 amp. [= square root of $(68^2 + 94^2)$]. The zero-load voltage corresponding to 116 amp. of field current is found from the saturation curve to be 2400 v. The regulation is therefore $(2400 - 2000) \div 2000 = 0.20$, or 20 per cent.

COMPARISON OF METHODS FOR CALCULATING VOLTAGE REGULATION

THE 2 METHODS for calculating regulation are based on assumptions that differ widely from conditions actually existing in an alternator, and the only satisfactory way to compare the 2 methods is to compare the results of calculations with actually observed values of voltage regulation. The electromotive force method generally gives a poorer regulation, while the magnetomotive force method generally gives a better regulation than is found by actual test; for this reason, the former is called the "pessimistic" method and the latter the "optimistic."

WHEN THE United States revenue cutter "Seminole" was being overhauled at Arundel Cove, Md., recently, it was found that the ship's old boilers would have to be removed and new ones substituted in their place. These had originally been set while the vessel was in the course of construction, and to lift them out bodily it would have been necessary to tear out a large section of the upper deck. As it was, the work was accomplished quickly by cutting the boilers into strips with oxyacetylene torches. Two men, each with a torch, cut through approximately 1000 ft. of steel plate, averaging 1 in. in thickness, in 30 working hours. The new boilers were lowered in sections and riveted together.—Popular Mechanics.

Testing for Grounds on a Secondary 3-Phase Line

By E. C. Parham

FIGURE 1 illustrates the connections of 3 single-phase transformers as operated on a 3-phase supply circuit. Both the primary and the secondary are star connected; the primary neutral is maintained isolated, but the secondary neutral is perfectly connected to ground in order to realize certain advantages incident to that connection. It will be noted that, when a secondary is grounded, an insulation fault to ground on any of the phase wires, as at G_1, G_2, or G_3, will cause a short circuit and will blow the fuse of whichever line is involved.

In a certain instance, an operator called in an inspector to locate a ground on a 3-phase distributing line which served a number of mill motors. The inspector did not give the matter of grounded neutral any attention. In applying a test wire, such as t^1 in Fig. 2, to

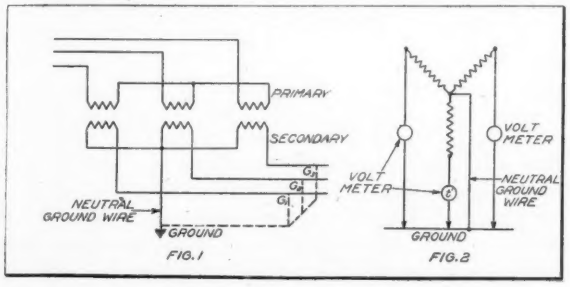


FIG. 1. CONNECTIONS OF 3 SINGLE-PHASE TRANSFORMERS WITH GROUNDED NEUTRAL

FIG. 2. METHOD OF DETERMINING GROUND

flash the 3 wires of the 3-phase line to ground one at a time, all 3 bashed, indicating a short circuit. Then, suspecting the cause, the inspector applied a voltmeter between each phase wire and ground, and in each case measured about 133 v. Since 230 v. was the line voltage given by the secondaries of 2 transformers in series, the voltage of a single coil was equal to $230 \div \sqrt{3} = 133$ v. This value, being equal to that measured by the voltmeter, indicated that the voltmeter was figuratively applied across the secondary of one transformer. A grounded neutral, on the secondary side of the transformer, is the only possible condition that would permit of the voltmeter reading a voltage between any line and ground equal to the secondary voltage of only one transformer.

The possibility of a man getting burned when applying test lines to a transformer in service, the neutral of which is grounded without his knowledge, is evident. For this reason, a test for grounded neutral should be the first one to be applied in the absence of any previous information as to whether it is grounded or not.—General Electric Review.

"THE GREATEST impediment in any man's way," says Edward Mott Woolley, "is the fog of tradition that hems in and prevents his reaching out boldly, with untainted mind, for the truth."

Practical Electrical Engineering

DETAILS OF HIGH-TENSION A.-C. SWITCHBOARDS

SWITCHBOARDS for high-tension work differ considerably from those for voltages of 2500 and under described in previous articles. They are generally designed to meet special requirements and do not conform so closely to standard designs as the low-tension boards. The general arrangement is to mount the controlling instruments on a desk or bench board located so that the operator commands a view of the operating room. The feeder panels more nearly resemble the low-tension panels and are usually placed near the control desk. Oil switches and busbars are located in masonry compartments where convenience dictates.

With but few exceptions many of the instruments used are the same in general design as those employed for low-tension purposes. Lightning arresters are the same in general design but a greater number of units are introduced between the circuits and the ground to furnish a greater number of air gaps; this is to prevent arcing over owing to the greater disruptive discharge. High-tension circuit breakers for voltages of from 15,000 to 20,000, consist essentially of a base upon which are mounted 2 spring-clip contacts which support 2 hard wood poles, one of which is longer than the other. The shorter pole is connected to the longer one by a hinge and is of such a length that when at the proper angle,

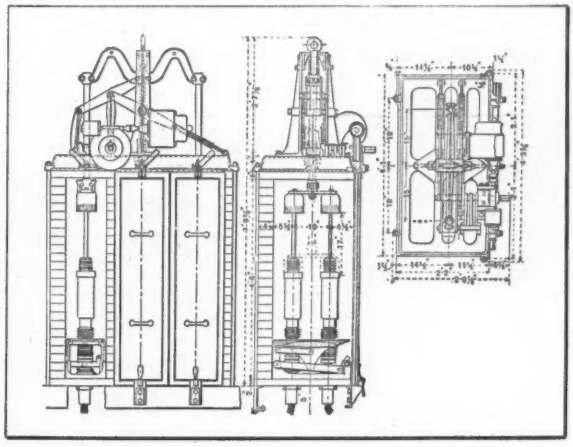


FIG. 1. OIL CIRCUIT BREAKERS

the upper ends are in line. At the upper end of each pole there is a cap sleeve supporting a round carbon contact block with holes in the centers. A wire running through the center of the short pole connects the carbon contact with the lower spring clip. A wire fuse, 6 to 10 in. long, connects the carbon contacts and when there is an excess of current, it "blows" and the spring forces the short pole outward. By grasping the end of the long pole, the combined mechanism can be removed from the spring clips for inserting a new fuse. A cord is used for mechanically detaching the fuse if it is desired to open the circuit in an emergency.

Indicating instruments of the electrostatic type, especially voltmeters and ground detectors, are largely used for high-tension work. These instruments depend for

operation upon the repulsion or attraction of 2 surfaces carrying electrostatic charges. One type consists of a set of fixed quadrants mounted so that an aluminum vane may swing on a pivot between them. The fixed set of quadrants is connected to one side of the circuit and the swinging vane to the other, so that when they become charged, the vane is attracted and drawn in between the quadrants, the voltage being indicated by the pointer. These instruments have the advantage that they require no current whatever for their operation. This is sometimes of importance, especially when the instrument is connected to an extremely high-potential circuit and left connected continuously. A small amount of current in such cases might represent a considerable loss of energy.

Oil switches for high-tension circuits are the same in principle as those for lower voltages with the exception that they are built on the unit plan, the switching

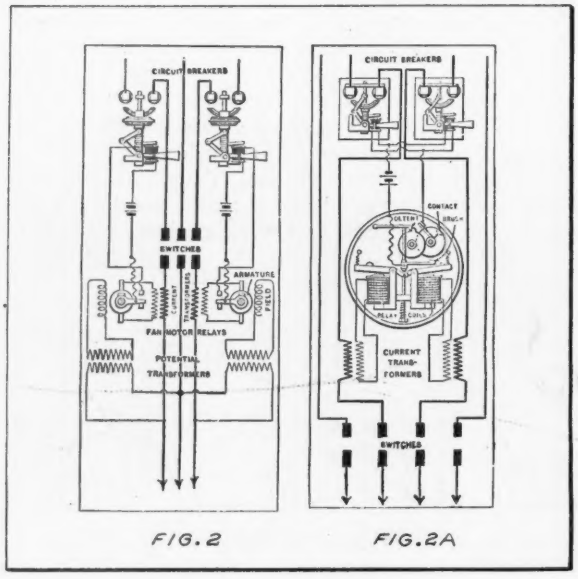


FIG. 2. DIAGRAM OF A REVERSE-CURRENT CIRCUIT BREAKER
FIG. 2A. DETAILS OF A TIME-ELEMENT RELAY

mechanism for each phase being enclosed in individual masonry cells to eliminate any possible danger of short circuits. The busbars are also separated in concrete or masonry compartments for the same purpose.

Continuity of service is highly important in all large power installations, therefore it is customary to run more than one set of feeders between the power house and substations. As a rule, where there are 2 sets of feeders, both are kept connected so that if trouble occurs on one its protective devices will cut it out and leave the other feeder intact. It will be apparent that if a short circuit occurs on one feeder, current will rush from the station in 2 directions, over the short-circuited feeder and over the auxiliary feeder through the substation to the short circuit; this would open all of the protective devices making the auxiliary line useless.

To eliminate such troubles, reverse-current circuit breakers are generally located at the substation end of the lines. This type of instrument opens only when the current flows in one direction; under these conditions, the main circuit breakers at the station and the reverse-current circuit breakers at the substation, connected to the defective line or feeder, will open, and those connected to the unaffected line will stay closed and the current will remain continuous. The circuits of a reverse-current circuit breaker set, showing how a direct-current motor is used with alternating currents to distinguish power passing in one direction and power passing in the other direction in the line, are shown in Fig. 2.

It is sometimes desirable to prevent circuit breakers from opening instantaneously upon overload. To prevent this, time-element relays are used in connection with them which have a mechanism so constructed that a variable time element can be introduced, the length of time before the opening of the breakers depending upon the adjustments. The details of a time element relay are shown in Fig. 2A.

High-tension line entrances to the power house and substations are of great importance, especially for high

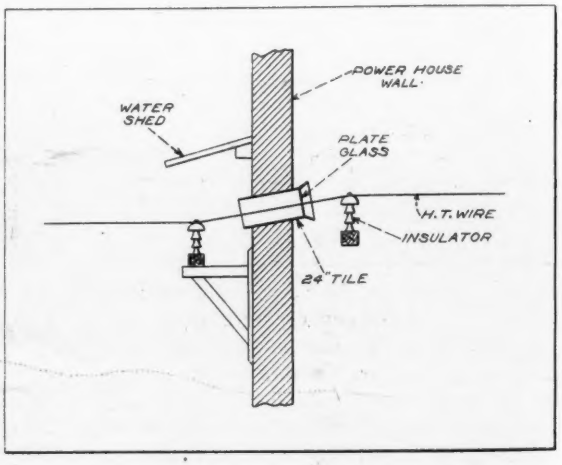


FIG. 3. METHOD OF CARRYING A HIGH-TENSION LINE THROUGH A WALL

voltages. A typical entrance for a 50,000-v. transmission line is shown in Fig. 3. The wires are anchored on the outside and on the inside of the building on high-tension insulators and pass through a hole in the center of a disk of plate glass held on the inside end of a 24-in. tile.

In some high-tension stations dial synchroscopes mounted on pedestals are used. Such instruments can be seen for some distance and have a miniature incandescent lamp on the end of the pointer. The mechanism of the large instruments is essentially the same as that of the smaller ones described in a previous article.

In high-tension generating stations, reliance is not placed on one oil switch for opening the circuit of any one machine or feeder, there usually being 2 or more switches connected in series. Only one of the series of switches, however, has an automatic circuit breaking attachment. Furthermore, the arrangement of connections is such that a great flexibility of machine and feeder connections is made possible.

Electric Towing System for the Panama Canal Locks

METHODS EMPLOYED; DETAILS OF TRACK; CONSTRUCTION OF LOCOMOTIVES; OPERATION OF LOCOMOTIVES

AFTER a thorough study of the entire problem of maneuvering ships through the locks of the Canal, it became evident that they should not proceed through the locks under their own power, and that a substitute for the ship's power should embrace the following requirements: (a) ability to place the ship in proper relation to the lock; (b) capability of keeping the ship to its course; (c) accelerating and retarding the ship without rupturing the lines; (d) the lines when once attached should be used without change for lockage in flight; (e) a small number of skilled operators rather than a large number of unskilled men to co-ordinate.

The towing system described in the following pages was designed and patented by Edward Schildhauer, Electrical and Mechanical Engineer of the Isthmian Canal Commission; and the 40 towing locomotives and all the electrical apparatus for operating the locks, were built by the General Electric Co.

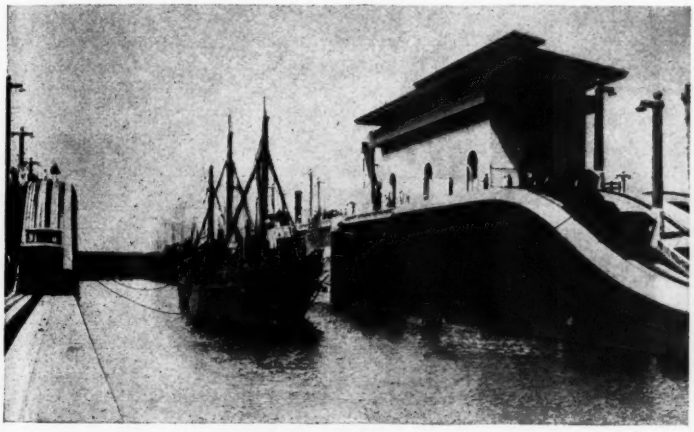


FIG. 1. OPERATION OF GATUN LOCKS; U. S. S. "SEVERN" LEAVING UPPER CHAMBER IN TOW OF ELECTRIC LOCOMOTIVES

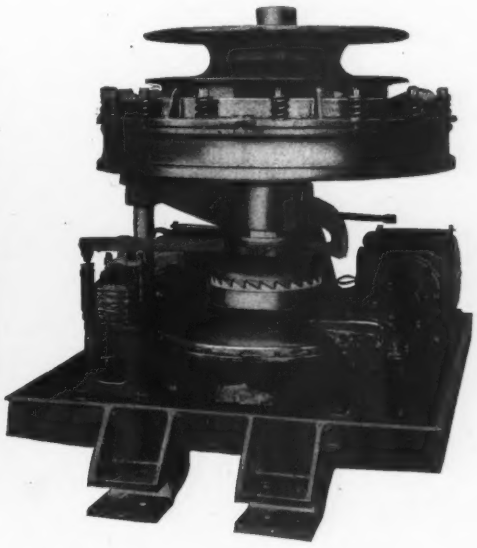


FIG. 6. WINDLASS AND BASE ASSEMBLED COMPLETE

TOWING SYSTEM

IN PASSING through the Canal from the Atlantic to the Pacific, a vessel will enter the approach channel in Limon Bay, which extends to Gatun, a distance of about 7 miles. At Gatun it will enter a series of 3 locks in flight and be raised 85 ft. to the level of Gatun Lake. It may then steam at full speed through the channel in this lake, for a distance of 24 miles, to Bas Obispo, enter and pass through the Culebra Cut, and reach Pedro Miguel, where it will enter a lock and be lowered 30 ft. Then it will pass through Miraflores Lake for a distance of 1½ miles until it reaches Miraflores, where it will be lowered 55 ft. through 2 locks, to the sea level, after which it passes out into the Pacific through an 8½-mile channel.

The main features of all the lock sites are identical; and the following brief description of the Gatun Locks is given to enable the reader to obtain a clearer conception of the towing scheme in general. In the general layout the Gatun Locks are 2 ship channels, one for traffic in each direction, separated by a center wall, the total length of which is 6330 ft. There are 2 systems of tracks, one for towing and the other for the return of the locomotive if idle. This, however, refers only to the outer walls. For the center wall, there is only one return track in common for both the towing tracks. The towing tracks are naturally placed next to the channel side, and the system of towing utilizes normally not less than 4 locomotives running along the lock walls. Two of them are opposite each other in advance of the vessel, and 2 run opposite each other following the vessel, the number of locomotives being, however, increased when the tonnage of the ship demands it.

Cables extend from the forward locomotives and connect with the port and starboard sides respectively of the vessel near the bow, while other cables connect the rear locomotives with the port and starboard quarters of the vessel. To place the vessel substantially in mid-channel the lengths of the various cables are adjusted by a special winding drum on the locomotive. When the leading locomotives are started, they will tow the

vessel, while the trailing locomotives follow and keep all cables taut. By changing the lengths of the rear cables, the vessel can be guided; and to stop the vessel, all the locomotives are slowed down and stopped, thus bringing the rear locomotives in action to retard the ship. The vessel, therefore, is always under complete control independent of its own power, and danger of injury to lock walls and gates is greatly lessened.

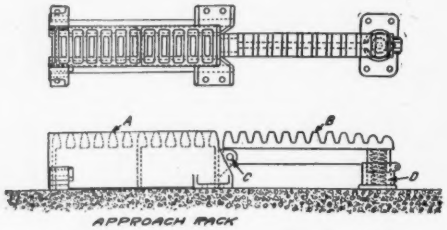


FIG. 2. RACK RAIL DETAIL

The towing tracks have a specially designed rack rail extending the entire length of both towing and return tracks, and located centrally with respect to the running rails.

A similar rail is also provided on short portions of the return track so as to lower the locomotives safely from one level to the next. A small portion of this is shown in Fig. 2, A being the rail proper while B the approach to it is hinged at C so that it can be depressed on the approach of the rack pinion of the locomotive, spring D restoring it to its proper position after the locomotive has passed over. A further feature of the rack rail is the projecting edges, which permit thrust wheels attached to the locomotive to run along the under side and prevent overturning of the locomotive, due to any excessive pull on the towline. These thrust wheels serve to counteract the lateral component of the towline pull and the flanges act for emergency only, as the weight of the locomotive is sufficient to prevent overturning with a normal pull of 25,000 lb. on the towline.

Three-phase, 25-cycle, 220-v. alternating current is used for operating the locomotives, and is supplied through an underground contact system. The collecting device is adjacent to the running rail on the side remote from the lock. Two T-rails form 2 legs of the 3-phase circuit while the third leg is formed by the main track rails. A specially designed contact plow slides between the 2 T conductors, transmitting power from rails to locomotive.

Locomotive Design

The working parts of the locomotive are supported by 2 longitudinal upright side frames, 1, Fig. 4, of cast steel, connected by transverse beams, 2, Fig. 5. These frames are in effect deep rigid trusses, having upper and lower members connected by posts 5, and diagonal braces 6, Fig. 4. The middle portion of each frame has its upper and lower members parallel and horizontal, but the end portions have their lower members inclined upwardly towards the ends of the frame. Pedestals 7, for the wheel axles 8, are located at the junction of these end portions with the middle portion, and are of the usual locomotive type, having vertical parallel jaws between which journal 9, slides. Springs, 10, are interposed between the tops of the journal boxes and the tops of the pedestals, and the locomotive is thus mounted upon 4 wheels, 11, carried on 2 axles, 8, the wheelbase being 12 ft. and the overall length of locomotive over 32 ft. Each axle is driven by its own motor, independent of the other; the construction is identical at both ends of the machine.

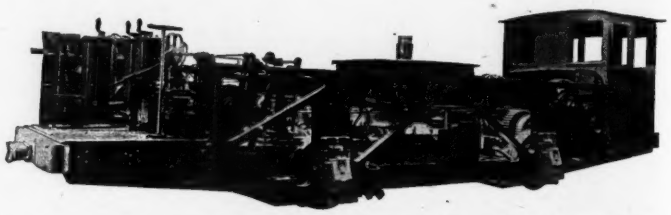


FIG. 3. SIDE VIEW WITH COVERS AND ONE CAB REMOVED, SHOWING CONTROLLERS AND FRONT OF PANEL; PANAMA TOWING LOCOMOTIVE

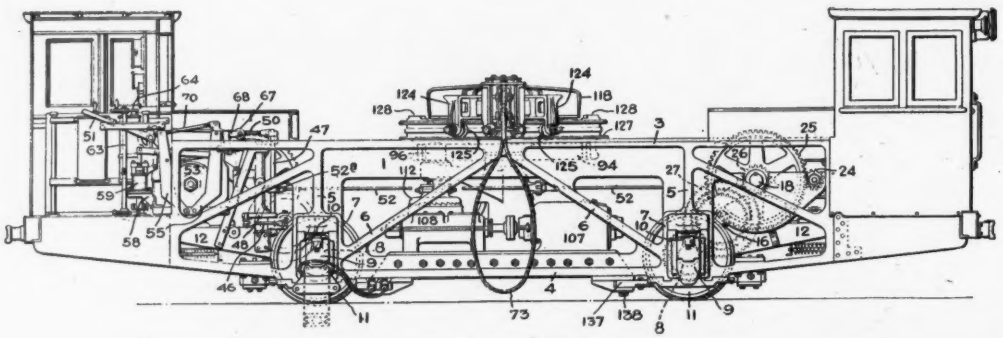


FIG. 4. SECTIONAL VIEW OF TOWING LOCOMOTIVES

The motor is of the 3-phase, slip-ring enclosed type, geared by a pinion and spur gear to a countershaft, carrying a pinion meshing with a spur gear, keyed to a jack shaft. On the outer side of this spur gear are formed clutch teeth which co-operate with similar teeth on the adjacent side of a gear, sleeved upon the jack shaft and which can be slid lengthwise thereon to engage and disengage the clutch teeth. A pinion wide enough to mesh always with this gear is keyed to the axle, so that when the clutch teeth are engaged the motor will propel the locomotive by the adhesion between the

wheels and the rails of the track, this only when running without load and between inclines.

When the locomotive, however, reaches one of the inclines between the locks, the grade of which may be as much as 44 per cent, or when towing, the cog-rail system is utilized instead so as to enable the locomotive to climb the grade and exert the necessary pull.

The 2 traction motors are controlled by suitable controllers installed in the cabs at the ends of the locomotives; and the circuits are such that both motors can be controlled from either cab, and can be operated singly or in multiple as desired.

Each motor, with all its gearings and clutches, is mounted independently of the frame of the locomotive, to which it is connected only by springs, giving an elastic support for the outer end of the bracket, on which the mechanism is carried.

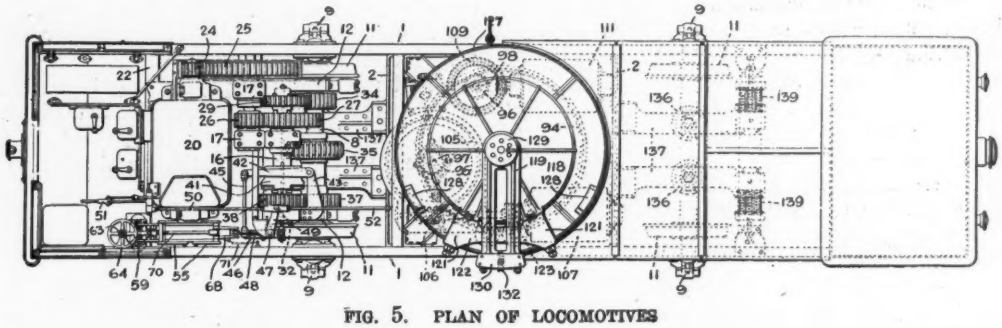


FIG. 5. PLAN OF LOCOMOTIVES

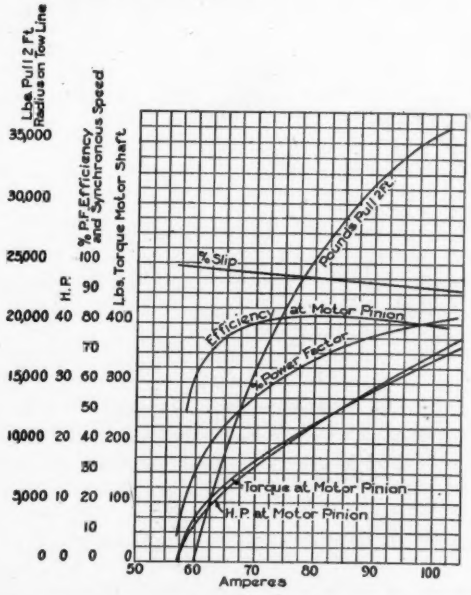


FIG. 7. CHARACTERISTIC CURVES OF WINDLASS MOTORS

In connection with each motor, a powerful brake is installed; and, as during operation the motors are at all times geared either to the axles or to the cog wheels, the truck wheels are not provided with any brake rigging. On the motor shaft is keyed a brake disk or drum, and to opposite sides thereof are applied the brake shoes. The movable core of a solenoid is pivoted to the long arm of a lever, which is fulcrumed on one of the brake levers. A rod connects the angle of this lever with the other brake lever, thus constituting a sort of toggle between the 2. When the core of the solenoid drops, it actuates the lever and the rod in such a manner as to draw the 2 brake levers towards each other and thereby apply the brake shoes to the drum. The winding of the solenoid is in circuit with the controller of the motors, so that when the current is turned on to energize the motor windings, the solenoid will lift its core and thereby release the brakes. The first point of the controller raises the brakes without applying power to the motors, thereby providing a coasting point. But should the motor current be shut off, either intentionally or accidentally, the core will instantly drop by gravity and its weight will exert a powerful leverage upon the brake levers to stop the motor and the locomotive. This action occurs simultaneously on both motors, and brake action is powerful enough to stop the locomotive within 2 revolutions of the wheels.

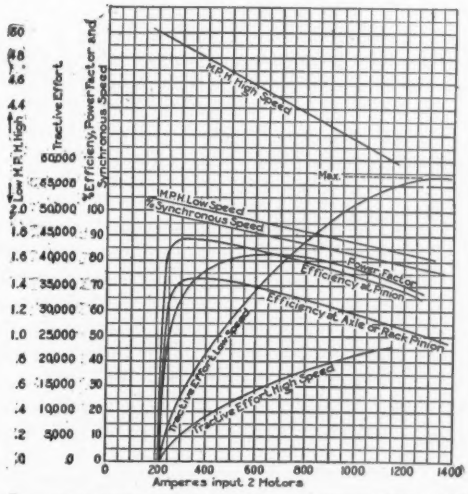


FIG. 8. CHARACTERISTIC CURVES OF TRACTION MOTORS

In addition to this automatic brake, means are provided for applying the brakes manually in order to supplement the action of the automatic feature, if necessary, when descending a grade or when approaching a rack rail.

While the hand and solenoid brake mechanism operate entirely independently of each other, both apply braking through the same levers and wheel.

The drum on which the towing cable is wound, is located midway between the ends of the locomotive, as

shown in Fig. 4, so that the cable can be led off on either side of the machine and through a wide range of angles to the line of travel.

For driving the drum at a high speed when taking in cast-off cable, a motor with bevel gear pinion is used, while another motor with worm gear drive is employed for taking in the cable when it is under load, and the drum operates as a windlass or capstan.

One of the most important parts of the locomotive is the "slip-friction" device, consisting of 2 special alloy rings, mounted on a spider and having between them a steel disk fastened to the rope drum. The amount of tension on the tow line is adjusted by the pressure between these 3 disks, obtained by tightening the spiral springs on the clamping ring. In order, therefore, to make the slipping tension of the towline proportional to the pressure between the friction disks, a rubbing surface having an absolutely constant coefficient of friction is essential. To find such a metal, certain tests were made and a metal having a friction coefficient of 0.1 under all pressures and condition of surfaces was selected for the work. This metal also showed but little difference in coefficient between starting and running. The results of the special tests were furthermore amply verified by the final test of the friction disks of each machine under full rated towline pull of 25,000 lb. by means of a dynamometer testing outfit. All 40 machines were given this slip test 25 times from each cab, and all passed the Government requirement not to exceed a variation of 5 per cent above or below the normal of 25,000 lb.

In connection with the slip test, further data on the slow winding motor was obtained as per curves in Fig. 7. The winding motor is a 20 hp. (1 hr. rating), 3-phase, high torque, squirrel cage type, induction motor controlled from a drum type reversible controller in either of the 2 cabs. From the curves it is seen that the motor has ample power to take care of any sudden pull on the towline up to 40,000 lb., which is well above the normal requirement of 25,000 lb. The speed of winding is at the average rate of 12 ft. per min.

The rapid-coiling motor is permanently geared to the drum and is of the same type, size and capacity as the winding motor. It is subjected to its maximum load when accelerating the heavy drum to the high speed required for coiling or paying out the rope, this being 16 times the slow winding speed at full load, or about 200 ft. per min.

The slow-winding and the rapid-coiling motors are operated by similar controllers and the circuits electrically interlocked so as to prohibit application of power to either motor unless the controller of the other motor is in the "off" position.

Each of the 2 main traction motors has a rating of 75 hp., and is of the slip-ring induction type, operated by a system of contractors with master controller in each cab. The motors, by means of the change in gearing from straight traction to rack rail towing previously described, drive the locomotive at a speed of 2 miles per hour when towing and 5 miles per hour when returning idle. These motors act as induction generators running above synchronous speed when the locomotive is passing down the steep inclines and thereby exert a retarding brake effect to keep the speed uniform. Speed, tractive effort and efficiency tests were made with results as shown by the curves in Fig. 8.

Using Logarithms

Quick Work for Multiplying, Dividing and Finding Powers and Roots

A LOGARITHM is the power to which a given number, called a "base," must be raised in order to produce another given number. Suppose we choose 10 as our base, we say that 2 is the logarithm of 100 (commonly written, log 100 = 2), because we must raise 10 to the second power—that is, square it—in order to produce 100. Likewise, 3 is the logarithm of 1000, for we must raise 10 to the third power, thus $10 \times 10 \times 10$ or 10^3, to produce 1000. In the same manner we can readily see that the logarithm of 10,000 is 4, of 100,000, 5, and so on.

The Base and the Log

The base of the common system or Briggs logarithms is 10; of the Naperian or natural system it is e or 2.7. The latter is, however, seldom employed except for figuring mean pressure on the hyperbolic expansion curve of a proposed indicator diagram.

From the above we see that the logarithms of such numbers as 100, 1000, 10,000, etc., are easily detected; but suppose we have a number such as 300, then the difficulty of finding its logarithm is apparent. We have seen that 10^2 is 100 and 10^3 equals 1000, therefore, the number 300, which lies between 100 and 1000 must have a logarithm which lies between the log of 100 and the log of 1000, namely 2 and 3 respectively. Reference to the accompanying table of logs shows us under N in the upper left-hand corner that for 300 the value is 477,121, or as will directly be shown, log 300 = 2.477,121, which means that 10 raised to the power of 2.477,121 = 300; $10^{2.477,121} = 300$.

Characteristics and Mantissa

The whole number in a log, for example, the 2 in the above case, is called the characteristic, and the decimal part of the log, namely 0.477,121, is the mantissa. It will be noted that 300 is composed of 3 figures and that the characteristic is 2, which suggests the fact that when a number whose log is desired is composed of 3 figures on the left of the decimal point the characteristic is 2; if the number is composed of 4 figures the characteristic will be 3, and so on. This rule may be stated as follows: For any number, the characteristic of its log has a value one less than the figures in that number to the left of the decimal point. Since it is easy to determine the characteristic, only the mantissa or decimal point is included in the tables.

The mantissas of the logs of numbers containing the same figures, such as 3.234, 32.34, 323.4 or 3234 are all the same, only the characteristic being different, thus:

log 3.234 = 0.509740; log 32.34 = 1.509740; log 323.4 = 2.509740; log 3234 = 3.509740.

If, however, we want the log of 0.3234, we first write down the characteristic, which in this case would be —1. As there are zero places to the left of the decimal point, one less than zero is —1. Then as we know our mantissa is .509740, the log of 0.3234 would be —1.509740. If our number should be 0.03234, the log would be —2.509740, and so forth.

Use of Logarithms

Understanding the nature and meaning of a log we can now investigate its uses. Let us see how powers of numbers may be multiplied and divided.

$2^2 = 2^1 \times 2^1 = 2 \times 2$. $2^3 = 2^2 \times 2^1 = 2 \times 2 \times 2$. $2^4 = 2^3 \times 2^1 = 2^2 \times 2^2 = 2 \times 2 \times 2 \times 2$; and so on. Examining, we note that in each case the exponent of the higher power is the sum of the exponents of the lower powers, which are its factors, thus $2^2 = 2^{1+1}$; $2^3 = 2^{2+1}$; $2^4 = 2^{3+1} = 2^{2+2}$. This is a universal law.

The product of any powers of any number equals that same number with an exponent equal to the sum of the exponents of the factors. In other words, multiplication is accomplished by adding exponents.

For division, the reverse is true.

$$2^4 \div 2 = 2^4 \div 2^1 = 2^{4-1} = 2^3 = 2 \times 2 \times 2$$
$$2^4 \div 2^2 = 2^{4-2} = 2^2 = 2 \times 2$$
$$2^3 \div 2 = 2^3 \div 2^1 = 2^{3-1} = 2^2 = 2 \times 2$$
$$2^3 \div 2^2 = 2^{3-2} = 2^1 = 2$$

or to divide any power of any number by any other power, the quotient will equal that same number with an exponent equal to the exponent of the dividend minus the exponent of the divisor.

Multiplication

Suppose we are to multiply 336 by 5380; we find that log $336 = 2.526{,}339$ or $336 = 10^{2.526,339}$; and that log $5380 = 3.730{,}782$, or $5380 = 10^{3.730,782}$. Then 336×5380 is the same as $10^{2.526,339} \times 10^{3.730,782}$. But $10^{2.526,339} \times 10^{3.730,782} = 10^{2.526,339+3.730,782} = 10^{6.257,121}$. We have simply added the exponents, remembering that these exponents are the logs of 336 and 5380 respectively.

In order to find what number $10^{6.257,121}$ is equal to, we refer to a table of logs and see that the mantissa 0.2571 corresponds to 1808; which at present is as far as we will carry it. Interpolation is fully explained later. The characteristic, 6, tells us that there must be 7 places to the left of the decimal point; therefore, $10^{6.257,121} =$ 1,808,000, approximately.

Any number may be multiplied in this manner; thus, if we desire to multiply $217 \times 4876 \times 3.185 \times 0.0438 \times 890$, we have

log 217	=	2.3365
log 4876	=	3.6880
log 3.185	=	.5031
log 0.0438	=	—2.6415
log 890	=	2.9494
Adding, we have		8.1185

Note that in adding the column of characteristics the value —2 must be subtracted from the sum of the other figures.

We must now find the number corresponding to the log 8.1185, and from the table obtain 131,400,000, which therefore is the result of the above multiplication.

Division

To divide one number by another we subtract the log of the latter from the log of the former; that is, subtract exponents of the powers of 10 equal to the numbers.

Thus, $3865 \div 735$ is accomplished as follows:

log 3865 = 3.5872	$3865 = 10^{3.5872}$
log 735 = 2.8663	$735 = 10^{2.8663}$
Difference 0.7209	

The tables show that 0.7209 is the log of 5.259; therefore

$$3865 \div 735 = 5.259.$$

SECTION OF LOGARITHMIC TABLE AND PROPORTIONAL PARTS*

[No. 300 L. 477.] [No. 339 L. 531.

N.	0	1	2	3	4	5	6	7	8	9	Diff.
300	477121	7266	7411	7555	7700	7844	7989	8133	8278	8422	145
1	8566	8711	8855	8999	9143	9287	9431	9575	9719	9863	144
2	480007	0151	0294	0438	0582	0725	0869	1012	1156	1299	144
3	1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	143
4	2874	3016	3159	3302	3445	3587	3730	3872	4015	4157	143
5	4300	4442	4585	4727	4869	5011	5153	5295	5437	5579	142
6	5721	5863	6005	6147	6289	6430	6572	6714	6855	6997	142
7	7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	141
8	8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	141
9	9958										
		0099	0239	0380	0520	0661	0801	0941	1081	1222	140
310	491362	1502	1642	1782	1922	2062	2201	2341	2481	2621	140
1	2760	2900	3040	3179	3319	3458	3597	3737	3876	4015	139
2	4155	4294	4433	4572	4711	4850	4989	5128	5267	5406	139
3	5544	5683	5822	5960	6099	6238	6376	6515	6653	6791	139
4	6930	7068	7206	7344	7483	7621	7759	7897	8035	8173	138
5	8311	8448	8586	8724	8862	8999	9137	9275	9412	9550	138
6	9687	9824	9962								
				0099	0236	0374	0511	0648	0785	0922	137
7	501059	1196	1333	1470	1607	1744	1880	2017	2154	2291	137
8	2427	2564	2700	2837	2973	3109	3246	3382	3518	3655	136
9	3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	136
320	5150	5286	5421	5557	5693	5828	5964	6099	6234	6370	136
1	6505	6640	6776	6911	7046	7181	7316	7451	7586	7721	135
2	7856	7991	8126	8260	8395	8530	8664	8799	8934	9068	135
3	9203	9337	9471	9606	9740	9874					
							0009	0143	0277	0411	134
4	510545	0679	0813	0947	1081	1215	1349	1482	1616	1750	134
5	1883	2017	2151	2284	2418	2551	2684	2818	2951	3084	133
6	3218	3351	3484	3617	3750	3883	4016	4149	4282	4415	133
7	4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	133
8	5874	6006	6139	6271	6403	6535	6668	6800	6932	7064	132
9	7196	7328	7460	7592	7724	7855	7987	8119	8251	8382	132
330	8514	8646	8777	8909	9040	9171	9303	9434	9566	9697	131
1	9828	9959									
			0090	0221	0353	0484	0615	0745	0876	1007	131
2	521138	1269	1400	1530	1661	1792	1922	2053	2183	2314	131
3	2444	2575	2705	2835	2966	3096	3226	3356	3486	3616	130
4	3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	130
5	5045	5174	5304	5434	5563	5693	5822	5951	6081	6210	129
6	6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	129
7	7630	7759	7888	8016	8145	8274	8402	8531	8660	8788	129
8	8917	9045	9174	9302	9430	9559	9687	9815	9943		
										0072	128
9	530200	0328	0456	0584	0712	0840	0968	1096	1223	1351	128

Proportional Parts.

Diff.	1	2	3	4	5	6	7	8	9
139	13.9	27.8	41.7	55.6	69.5	83.4	97.3	111.2	125.1
138	13.8	27.6	41.4	55.2	69.0	82.8	96.6	110.4	124.2
137	13.7	27.4	41.1	54.8	68.5	82.2	95.9	109.6	123.3
136	13.6	27.2	40.8	54.4	68.0	81.6	95.2	108.8	122.4
135	13.5	27.0	40.5	54.0	67.5	81.0	94.5	108.0	121.5
134	13.4	26.8	40.2	53.6	67.0	80.4	93.8	107.2	120.6
133	13 3	26.6	39.9	53.2	66.5	79.8	93.1	106.4	119.7
132	13.2	26.4	39.6	52.8	66.0	79.2	92.4	105.6	118.8
131	13.1	26.2	39.3	52.4	65.5	78.6	91.7	104.8	117.9
130	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0	117.0
129	12.9	25.8	38.7	51.6	64.5	77.4	90.3	103.2	116.1
128	12.8	25.6	38.4	51.2	64.0	76.8	89.6	102.4	115.2
127	12.7	25.4	38.1	50.8	63.5	76.2	88.9	101.6	114.3

Powers and Roots

If we wish to square a number we simply multiply its log by 2 and then find the number of which the result is the log. If we wish to raise the number to the third, fourth or other power, we simply multiply by 3, 4, or other power as the case may be. Thus, suppose we wish to cube 9879; we have:

*Copies of the complete table[illegible] obtained for 10 cents by addressing the Standard Corpor[illegible]ansylvania Building, Philadelphia, Pa.

log 9879 = 3.9947; 3.9947 × 3 = 11.9841; 11.9841 is the log of 964,000,000,000, therefore 9879 cubed is 964,000,000,000, in round numbers.

Likewise, if we desire to find the square root, the cube root, or fourth root, or any root of a number, we simply divide its log by 2, 3, 4, or whatever the root may be. Suppose we wish to find the square root of 36,850, we have:

log 36,850 = 4.5664; 4.5664 ÷ 2 = 2.2832; 2.2832 is the log of 191.98, which therefore is the square root of 36,850.

Interpolation

When looking for the logarithm of a number containing 5 or more figures, or when looking up a number the logarithm of which contains 5 or more figures, it becomes necessary to interpolate, since the tables do not give these values directly.

Required the logarithm of 33.253. Looking at the page having 332 in the left-hand column, then following that line to the right to the number in the column headed 5, we find 1792, which with the 52 in the column under 0, gives 521792 as the mantissa for 3325. The difference between 1792 and 1922, the next highest, is 130, which is given in the right-hand column nearly opposite; 3/10 of this is 39, as shown by the table of proportional parts at the bottom of the page. Adding 39 to 521792 we have 521831 as the complete mantissa. The characteristic, by rule, is 1, and the complete value of the logarithm of 33.253 is 1.521831.

Required the number whose logarithm is 3.982882. Look at the page on which the first 2 numbers in the 0 column are 98. On the line opposite 961 are found the 4 numbers, 2859, which are next lower than those given, 2882, the next higher set being 2904. The 4th figure of the number is that at the top of the column above 2859, or 3, and the first 4 figures of the required number are 9613. 2882 — 2859 = 23. 2904 — 2859 = 45, which is shown in the margin. The table of proportional parts, on the 45 line shows that 23 is nearly 0.5 of 45. Therefore, 5 is the next figure, and the 5 significant figures are 96135. And since the characteristic is 3, the number must have 4 places to the left of the decimal point, and is 9613.5.

By interpolating, it is possible to carry our numbers to 6 figures instead of but 4, resulting in greater accuracy.

Unusual Blowoff

For a small upright boiler which could not be connected to the sewer or conveniently to a blowoff tank, a vertical riser pipe was carried to ground level, through the wall horizontal and turned up with a 45-deg. ell, nipple and a 2-in. cap. In the cap were drilled ⅛-in. holes to equal in area the 1-in. blowoff pipe, the holes being countersunk both sides to avoid clogging and give a spray nozzle effect. This spray rose to a considerable height and cooled before it fell on the driveway, so that no bad effect was produced. To clean the boiler, it was allowed to stand 48 hr. for cooling down, then emptied onto the concrete floor through the drip at the bottom of the vertical riser, and drained away by a hole in the center of the floor into the sand and gravel fill beneath.—Refrigerating World.

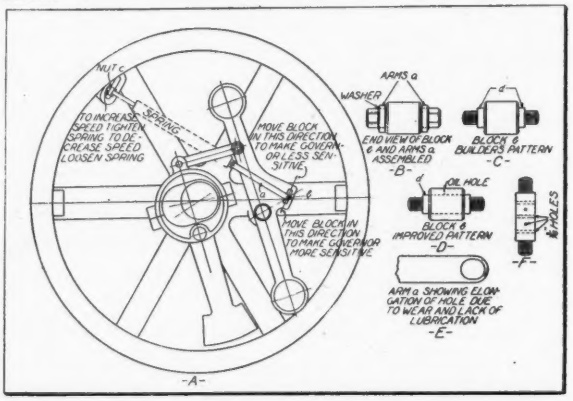
Trouble With a Gravity Balanced Inertia Governor

By C. E. Anderson

Sometime ago I was operating a plant wherein one of the generating units was a high-speed engine, direct-connected to a 250-kw. Crocker-Wheeler shunt wound generator. The engine was governed by a flywheel governor of the gravity balanced inertia type.

This engine gave us considerable trouble and annoyance after a short period of operation. It did not regulate very well and lost several revolutions a day. This condition was partly remedied by increasing the tension on the balance arm spring in the governor about once a week, by means of nut c in the sketch, which increased the tension of the spring, thereby bringing the engine up to the required speed.

At first, I thought that the trouble was caused by the nut backing off the spring tension bolt, so I placed a lock nut on the bolt; but the conditions remained the same.


NUT c
SPRING
TO INCREASE SPEED TIGHTEN SPRING TO DECREASE SPEED LOOSEN SPRING
MOVE BLOCK IN THIS DIRECTION TO MAKE GOVERNOR LESS SENSITIVE
MOVE BLOCK IN THIS DIRECTION TO MAKE GOVERNOR MORE SENSITIVE
-A-
ARMS a
WASHER
END VIEW OF BLOCK b AND ARMS a ASSEMBLED
-B-
BLOCK b BULLDOG'S PATTERN
-C-
OIL HOLE
BLOCK b IMPROVED PATTERN
-D-
4 HOLES
-F-
ARM a SHOWING ELONGATION OF HOLE DUE TO WEAR AND LACK OF LUBRICATION
-E-

GOVERNOR AND DETAILS WHICH GAVE TROUBLE

I had previously marked the lock nut and the other nut, also the bolt; and seeing, on examination, that the nuts had not moved, I decided I must look elsewhere for the trouble.

This unit was compelled to operate under these conditions for some time, as the load was too heavy to carry on the other machine alone.

One night, the governor started squeaking badly and the night engineer shut it down. When I came on in the morning, I started to strip the governor and before I had gone very far, I found the cause of the squeak, also the cause of the poor regulation of the engine and the loss of speed.

On removing the nuts and washers on block b, in sketch, I found the holes in the arms, a, badly worn and elongated, as shown in detail at E. This was caused by insufficient lubrication; there were no provisions made to oil the wearing surfaces between the arms, a, and the pin, d. This wearing away and elongation of the holes in the arms was the cause of the engine losing revolutions due to the regulating spring tension being decreased by this wearing away of the metal. This made it necessary to increase the spring tension continually to keep the engine up to the required speed.

An idea is given at C, of the construction of block b builder's design as found in the governor. d shows the relative sizes of the wearing surfaces that the arms, a, worked on. This movement is only a few degrees, but there is quite a strain or tension on this part of the governor, due to the pull of the spring on the arms; as there were no provisions for oiling these rubbing surfaces, it is quite evident that there will be considerable wear in a short time. The builder's pattern of block b was turned up from a solid piece of machine steel, as shown by C.

To remedy the trouble and overcome this lack of lubrication and excessive wear, I made another block, as shown at D. Instead of making the block and pin solid as the builder's pattern, I made the block and pin separate; that is, I planed up a block, as illustrated, bored a ¾-in. hole through the center of the block and fitted a ¾-in. pin into this hole. At either end of this pin, ½-in. threads ½ in. long were made for the nuts to hold the arms, a, for the pin.

The idea was to have the wearing surfaces increased in area. In this design, the wearing surfaces were made between the block, b, and the pin, F, which gives a greater area than in the builder's design where the wearing surfaces were between the arms, a, and the pin, d.

Five 3/16-in. holes were drilled through the pin, F, at right angles to each other. These holes were then filled with a stiff paste made of graphite and cylinder oil. The upper part of block b was drilled for an oil hole, so the pin could be lubricated with oil through this hole when the engine was stopped or before starting up. Between the hand oiling and the graphite paste working out of the pin onto the wearing surfaces, the pin was assured a sufficient amount of lubrication at all times.

A new pair of arms was made and the holes in them were made a light driving fit on pin d.

With the new pin, block and arms assembled, it will be seen that the wear and friction is between the pin, d, and the block, b, instead of the pin, d, and the arms, a, as before.

This new arrangement worked very satisfactorily and we never experienced any governor trouble on this unit due to wear at this point as long as I was connected with this particular plant.

What is Humidity?

By G. P. Pearce

WHILE talking at an Engineer's Club, the conversation happened to turn on the subject of humidity. The majority were of the opinion that it was moisture absorbed by the air, something like a sponge absorbing water; some thought it was an actual chemical combination that took place between the air and water, as oxygen and carbon combine to form carbonic acid gas, and one was strongly of the opinion that it simply was minutely divided or atomized water mechanically suspended in the air. Not one of them knew just how to figure out the weight of a cubic foot of saturated air at a given temperature, or the weight of the contained moisture.

There is nothing mysterious about humidity except, perhaps, its name, which is derived from a Latin word meaning "to be moist." Humidity is simply a way of talking about a mixture of air and steam. Let us take a tank that holds just one cubic foot and pump out all the air. We will also assume that the temperature of the engine room where we will make this experiment is 90 deg. F., which will be the temperature of the tank. Now let us inject a little water into the tank, and of course we all know what will happen; enough of it quickly evaporates into steam until the air becomes saturated for the temperature of 90 deg. F. We will next draw out all the surplus water and now have a cubic foot of saturated steam at a temperature of 90 deg. F., and if we had carefully weighed the tank before and after, on very sensitive scales, we could discover the weight of the cubic foot of steam. But there is no need for us to go to all this trouble, as we can find it all from the steam tables in our engineer's handbooks; by looking up the new Marks & Davis steam tables, we find for a temperature of 90.1 deg. F., which is near enough for this experiment, that a cubic foot of steam at this temperature, weighs 0.002,137 lb., and that the pressure is 0.698 lb. per sq. in. absolute. So now we know all we want about a cubic foot of steam under these conditions.

We will next pump out this steam and then let the tank fill with dry air, which we can get by letting the air suck in through some calcium chloride; this will completely dry it. We now have a cubic foot of dry air at 90 deg. F., which will weigh 0.072,197 lb., as we can find from a table of air weights; or we could get it by very accurately weighing the tank. The pressure we will take as 14.7 lb. per sq. in.

Now, it is known that the space above a liquid will always become saturated with its vapor until a balance is established, whether the space at the beginning is a vacuum, or is filled with a gas; in other words, the presence of gas has no effect upon the amount of vapor formed. Take water, for instance; the weight and pressure of the vapor for saturated steam formed over the surface of the water will build up to the same amount whether there is any air present or not. It seems as if there is plenty of room for the steam molecules to be present in the air without in any way interfering with one another. Let us then take our tank containing one cubic foot of air and inject some water into it. This will evaporate according to the above-mentioned law until the tank is filled with steam to the same weight and pressure as found when it was tested.

Starting from the vacuum this is 0.002,137 lb. at 0.698 lb. per sq. in. Taking out the unevaporated water we now have a cubic foot space with 0.002,137 lb. of steam and 0.072,197 lb. of air, a total weight of 0.074,334 lb., and the pressure inside will be 14.7 lb. absolute, due to the air and 0.698 lb. due to the steam, a total pressure of 15.398 lb. per sq. in. Next, we will open the valve and let enough of the mixture escape to reduce the pressure to atmospheric, or 14.7 lb. per sq. in. This we can easily figure, for it will be according to Boyle's law—

$$P_1V_1 = P_2V_2$$

Thus 15.398 lb. multiplied by 1 equals $14.7 \times X$, or

$$X = 1 \times 15.398 \div 14.7 = 1.0475 \text{ cu. ft.}$$

and the weight of one cubic foot will be equal to

$$0.074,334 \div 1.0475 = 0.070,95 \text{ lb.},$$

which is the weight of one cubic foot of saturated air (100 per cent humidity) at 90 deg. F.

We will now find the weight of water in the cubic foot of saturated air, which is easy, because we know that the original cubic foot of steam weighs 0.002,137 lb., and that due to its pressure combining with that of the air, it expanded to 1.0475 cu. ft. Therefore, the weight of the water or rather steam in the cubic foot of saturated air is $0.002,137 \div 1.0475 = 0.002,041$ lb., and the weight of the air of course is $0.070,95 - 0.002,041 = 0.068,909$ lb.

This is quite a simple calculation, and for any other temperature or pressure the method is just the same.

Layout of Special Cast-Iron Elbow

By J. H. Blakey

RECENTLY a question came up regarding the laying out of a special cast-iron elbow. The problem seemed rather perplexing at first sight, but was solved by the help of a little elementary mathematics.

A pump having a horizontal discharge was to deliver into a water main, also lying horizontal, but at

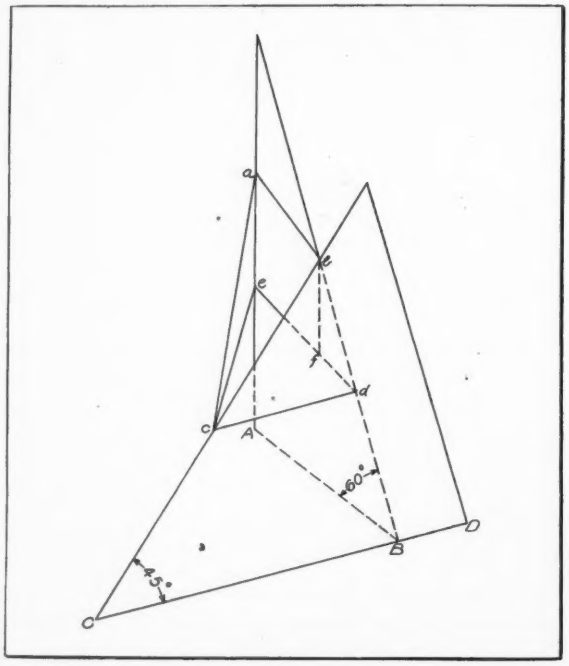


FIG. 1. PERSPECTIVE DIAGRAM SHOWING RELATIVE POSITION OF TRIANGLES

right angles to the center line of the discharge and at a lower level. In order to get an easy curve, it was decided to turn the lateral on the main through an angle of 30 deg. from the perpendicular toward the pump. The question was to find the angle of the connecting elbow. The horizontal distance from the face of the flange to the apex of the angle of the elbow was to be 24 in.; the length of the other leg would be determined by the length of the branch of the lateral, which would project at an angle of 45 deg. to the center line of the main, but must be at least 24 in.

Take a 45 and a 60-deg. triangle, and set them up at right angles to each other, as shown in Fig. 1, with the edges CD of the 45-deg. and AB of the 60-deg. triangles on the surface of the table, the 45-deg. triangle being in front and leaning against the diagonal side of the 60-deg. triangle, which is held perpendicular to the plane of the table. It will be seen that the base lines AB and CD are horizontal. Now draw a line ab from the point b, which is the point of intersection of the edges of the triangles, parallel to the base AB. This represents the center line of the pipe from the pump. Let this line represent 24 in. on any scale. On bC, strike off bc, equal to ab; the angle abc is the angle required, and the line cb represents the center line of the branch of the lateral.

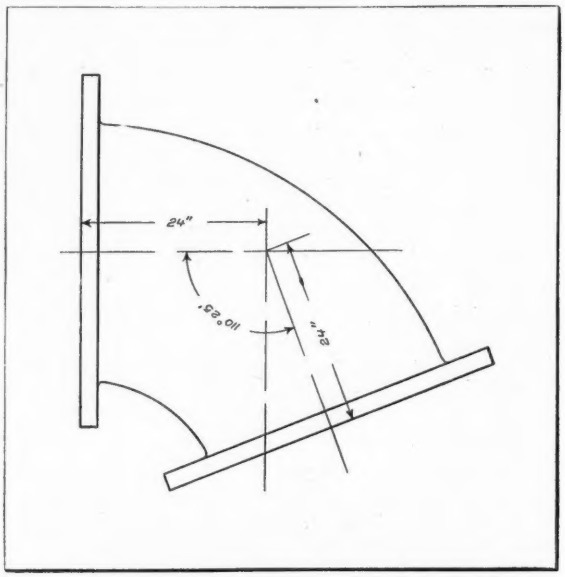


FIG. 2. CAST-IRON ELBOW MADE TO SUIT SPECIAL CONDITIONS

Draw cd parallel to CD, and de parallel to ab. Now, as cd and db are at right angles, and bc is at 45 deg. to each, bc is the diagonal of a square of which cd and bd are 2 sides. Consequently, they are equal, and the length of each is $24 \div \sqrt{2} = 16.97$ in.; ed is parallel to ab, and is greater than ab by half the amount of the base of an equilateral triangle of which bd is one side, because the angle bde is 60 deg. Consequently, $ed = 24 + (16.97 \div 2) = 32.48$ in. Now we have a plane triangle, dec, in which the angle edc is a right angle; $ed = 32.48$ and $cd = 16.97$ in.; therefore the hypotenuse $ec = \sqrt{32.48^2 + 16.97^2} = 36.65$ in.; and the perpendicular ea is equal to bf, which, as the angle bdf is 60 deg., is equal to $16.97 \times \sqrt{3} \div 2 = 14.69$. Then in the right-angled triangle eac we have $ea = 14.69$ and $ec = 36.65$; therefore the hypotenuse ac, which is the chord of the angle required, is equal to $\sqrt{(36.65^2 + 14.69^2)} = 39.42$. Now the chord is twice the sine of half the angle, so half of 39.42, divided by 24, which is the dimension we started with, gives 0.821,25. Looking up a table of natural sines, we find that the corresponding angle is between 55 deg. 12 min. and 55 deg. 13 min. Therefore the required angle is double of this, or 110 deg. 25 min., practically.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Vacuum Pump Stopped

"I DON'T know what is the matter with this pump," said the fireman, as I entered the plant on Sunday morning to look around.

"Well, how does it act?"

"When I push on this rod it just moves from one end to the other and comes back and stops."

After the fireman had repeated the operation, I noticed the casting on the rod which moves the rocker arm was a considerable distance from the center punch mark on the rod. Careful examination showed that this casting had moved 3 in. on the rod.

"It was running all right last night when I shut it down," said the fireman.

"Yes," I replied, "but did you notice anything strange about that casting? Is it in its right place?"

Taking a rule from my pocket to measure, I showed the fireman the distance the casting had slipped along

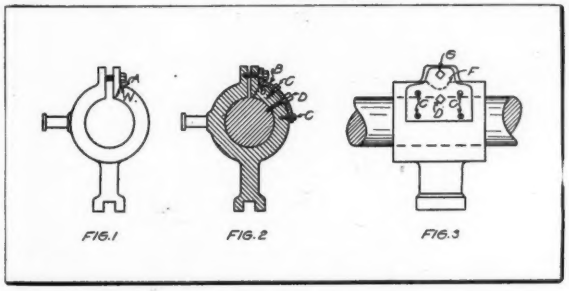


FIG. 1. BROKEN CLAMP RING ON PUMP PISTON ROD
FIG. 2. CROSS SECTION OF REPAIR TO CLAMP RING
FIG. 3. SIDE VIEW OF REPAIR

the rod toward the water end, and that it must be driven back into position and tightened up to keep it there. The bolt at the top, which clamped it together, was loose; yes, very loose, the clamp going right together at the top, revealing the crack at A in Fig. 1, and there was no spare unit to use, the temperature was down to zero weather and the factory from which a new casting must come, just halfway across the United States.

Only half of the entire heating was done on Sunday and, to insure service on the other half, the pump must be running by morning.

After searching the tool box for screws, taps and drills, I obtained a piece of tough strap iron about 3½ in. wide and the same length, cut it to the right size and bent it to the curve and shape as illustrated in Fig. 2—B being the strap, and C, C the screws which hold it onto the side of the casting.

But when the holes had been drilled in the plate and the plate put on the casting to mark off the holes to be tapped, it was found that the depression at N, Fig. 1, and F, Fig. 3, cut out to make room for the head of the bolt, G, must have the plate fitted into it low enough to allow the bolt head to turn above the plate. So the casting was filed off as at the dotted line, O, in Fig. 2. The plate, which was 5/64 in. in thickness, could be bent in any shape. As it was new and very tough, it was hammered, while cold, right down in the depression shown by the dotted line, F, in Fig. 3, which gave ample room for the bolt head, G, to turn around. Moving the top of the plate back from the break 1/32 in., the holes C, C and D were drilled and tapped and the screws tightened up. The casting had nothing to hold it to the shaft before but the friction of the clamping bolt, G, and, having allowed 1/32 in. for stretch of the thin plate, the bolt G was put in and tightened and the casting gripped the piston rod as usual, but the strap was very thin and soft and might work loose. To make sure the casting would not slip along the rod again, a hole was drilled through the side of the casting deep into the piston rod and tapped to the bottom for a ⅜-in. set screw, which was screwed through the strap, casting and into the piston rod as at D in Fig. 2. This screw not only prevented the casting from slipping along on the rod, but aided the strap strength in clamping it to the rod.

The job was completed in about 2 hr. and is still running, saving the cost of a new casting.

R. A. CULTRA.

Gravity Heating System

THIS IS the time of the year when everybody hates the engineer; he "ain't got no friends nowhere," and the colder it gets the more he feels like a pariah. In the summer, we are on speaking terms with most of our shopmates, but not at this season.

We have a good heating system; in the daytime we use exhaust steam at from an ounce to 2½ lb. pressure, according to the weather; at night, of course, we use live steam. We usually get along nicely in the dead of winter, at which time the heat is kept on 24 hr. a day.

What causes most of our trouble is the fact that the product manufactured is of metal of which there are many tons all through the shop. This mass of metal acquires a temperature which is an average of the day and night temperature, so if we have been running along with heat on only in the daytime and a sudden blizzard comes up, you might as well try to heat an iceberg for a few days. The room temperature certainly has inertia; that's one of the things that can't be taken care of in a heating formula. Of course, this inertia is in our favor during continuous cold weather when the heat is kept on night and day; at such times

it is easy to keep the rooms comfortable, even with an outside temperature of 10 or 15 deg. below zero.

Ours is a plain gravity system with a dry return. It worked fine for 12 yr.; but this fall, when we started up, it gave us trouble. The return water would load up in the coils, radiators and returns and the only way we could make the water flow to the receiver was to open the 2-in. vents on the receiver; then it would come by the barrelfuls. We went over the return lines, which are in tunnels, to see that they had not lost their pitch, with no improvement, last summer in overhauling the system.

We were struck with the brilliant idea of turning the exhaust of the receiver pumps into the receivers. This looked good, but its effect was to build up a pressure in the return lines greater than that in the coils and probably held the swing checks on the coil outlets shut; at least. it certainly held the water back. Since turning the pump exhaust back to the atmosphere, there is no sign anywhere of the coils or radiators loading up.

We have never been able to get gages for the heating system that would indicate within pounds the pressure on the mains. I suppose there are gages that will indicate accurately pressures of only a pound or two, but the ones we have will not. That, however, does not worry us any more. We know our steam pressure, now, to tenths of a pound. It is quite simple; we just tapped the heating main and screwed in a good thermometer which we tested and found correct at 212 deg.

We took from a steam table, pressures and corresponding temperatures, put them on a card and tacked it upon the window frame, close to the thermometer. We find by this means that we have not been carrying as much pressure as we thought we were; also that in moderate winter weather we can do a very satisfactory job of heating with no apparent pressure.

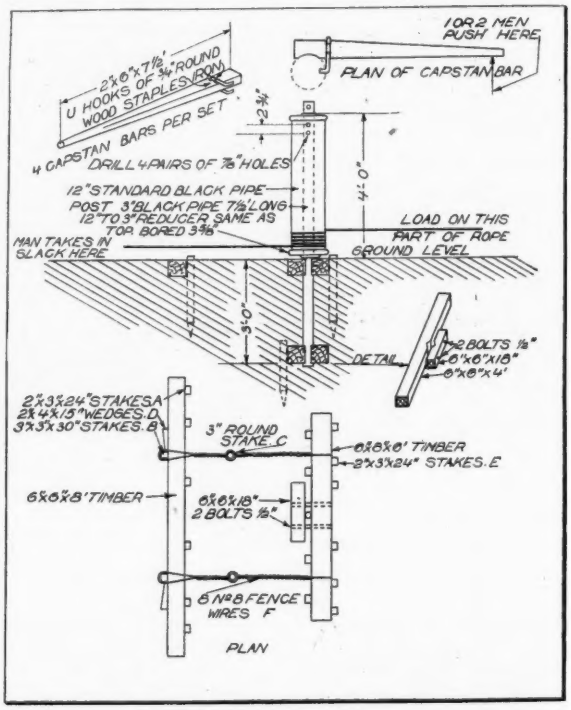
I figure it doesn't cost much to heat the shop while using exhaust steam. We will have to assume about everything except back pressure and indicated horsepower, but that is the way it looks.

We use exhaust from 168 i.hp. of engine; take back pressure at 2 lb. average, though it will not average that; mean effective pressure 40 lb.; cost of coal $1.80 a ton. Thus, $2 \div 40 = 5$ per cent increased load on engines; 5 per cent of 168 hp. $= 8.4$ hp. at 5 lb. coal per hp.-hr. $=$ 420 lb. in 10 hr. $420 : 2000 :: X : \$1.80$ or $420 \times \$1.80 \div 2000 = 37.8$ cents per day for fuel cost of heating one building, 100 by 150, 2 stories, one 40 by 300, one-story, one 40 by 70, 3 stories, one 170 by 40, 1 story, one 40 by 120, 2 story. J. O. Benefiel.

Home-Made Erecting Capstan

If we asked the business manager of the Blank Engine Co. what were the most necessary qualities for an erecting engineer to possess, he would mention many, such as honesty, good appearance, being a good mechanic, good with the indicator, etc., but would emphasize, "push the work diligently and finish it at small expense," and if he was not too busy he would describe J. J. Johnson, one of their men, who seems to have the knack of pleasing them and their customers. This fellow never howls to the customers about the hardships of his job, never tells them of the shortcomings of his firm or the defects of the machine he is erecting, nor fusses over the difficulty of getting the valves "just right" by the indicator, but reports all these things briefly as matters of fact to his employers; but while outside, he just goes on and works, always with a smile and a cheering word to his helpers, and does the best he can with everything, appears pleased with it and as a result the purchasers are also pleased.

Some of us could perhaps learn some things from Johnson if we would but sit up and take notice, for he has had a lot of experience. So, lately, when I saw him go to a plant to erect a lot of heavy machinery and practically nothing to move it with, and nothing in the town that could be borrowed, hired or bought, I was interested to see him get out a little sketch of a pipe capstan that had proved good in real work and rig it up as shown by the drawing herewith. It was built


1 OR 2 MEN PUSH HERE
PLAN OF CAPSTAN BAR
2"x6"x7½" U HOOKS OF ¾" ROUND WOOD STAPLES ROW
4 CAPSTAN BARS PER SET
DRILL 4 PAIRS OF ⅞" HOLES
2¾"
4'-0"
12" STANDARD BLACK PIPE
POST 3" BLACK PIPE 7½' LONG 12" TO 3" REDUCED SAME AS TOP BORED 3⅛"
LOAD ON THIS PART OF ROPE
MAN TAKES IN SLACK HERE
GROUND LEVEL
3'-0"
DETAIL
2 BOLTS ½" 6"x6"x18" 6"x6"x4'
2"x3"x24" STAKES A
2"x4"x15" WEDGES D
3"x3"x30" STAKES B
3" ROUND STAKE C
6"x6"x6' TIMBER
2"x3"x24" STAKES E
6"x6"x8' TIMBER
6"x6"x18" 2 BOLTS ½"
6 No 8 FENCE WIRES F
PLAN

PLAN, ELEVATION AND DETAILS OF CAPSTAN

up of old stuff that he gathered around the plant and in the local machine shop, having only a forge, an old lathe, a drill press of the country-blacksmith type and a bolt-cutter.

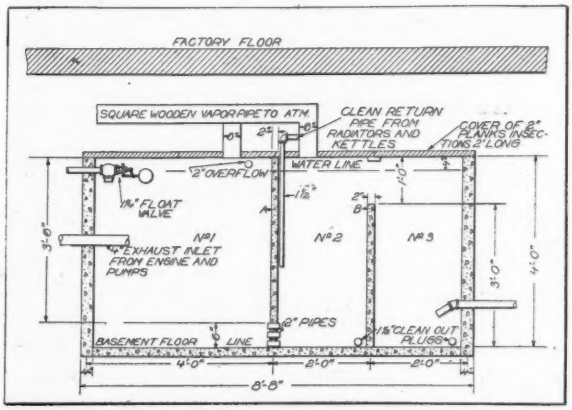
This man Johnson never forgets to consider cost, and so that is interesting to us, too. All the ground timbers he was able to pick up around the plant and the 4 ft. of 12-in. pipe he got there; but he had to take it to the shop and get it cut, buy the spindle and bolts and capstan bars and get the work done on them; this cost $5. The fence-wire, he got from the back of the lot without cash outlay. It also cost ½ day of his time, and 2 hr. of 2 laborers' time before it was erected, ready for operation.

With this simple device, he moved the cars on the siding back of the engine room, unloaded them, hauled the parts into the engine room and raised many of them into their final positions, over anchor bolts, etc., as there was no traveling crane up even when he left.

In addition to this pipe capstan, Johnson had 2 short screw jacks with square threaded screws about 2¾ in. in diameter, 2 double blocks and 100 ft. of ⅝-in. diameter hemp rope, and about as much 1-in. rope with a pair of double blocks, and about as much extra flexible wire rope ⅝-in. diameter, a few rollers, crowbars, an ax and small tools, and one single sheave block for the wire rope, with timbers and ties for blocking, but the work went right along and the final cost per ton of machinery erected was only $1.65 when he boarded the homeward bound train with the official "acceptance" in his pocket. F. W. SALMON.

Home-Made Concrete Feed Water Heater

WHEN I came to this plant I found there was no feed water heater of any sort, and although there was a receiver and pump for putting returns back to the boiler, there were no traps, and owing to the presence of cylinder oil from 2 small engines, they were not using the returns, but letting them go to waste, and as the law in Massachusetts requires that the feed water must enter the boiler at 150 deg. F., they were using an injector to feed the boiler with, and I saw at once that conditions were not good for the installation of any type of heater now on the market on account of lack of space to put it in; but I did ask why an oil separator had not been installed, and was told to devise some plan whereby an oil separator would pay for itself and be a benefit and they would buy it.



ELEVATION OF CONCRETE FEED WATER HEATER

I looked the place over and took everything into consideration and finally hatched out the plan, a sketch of which is enclosed herewith. The sketch shows a concrete tank 8 ft. long by 4 ft. wide by 4 ft. deep, with walls 6 in. thick. As first made, A was a partition starting 6 in. from the bottom and 4 ft. from one end of the tank and made a part of the main tank rising to the top of the side walls; B was another partition, 2 ft. to the right of the first, rising 3 ft. from the bottom. This gives 3 compartments—No. 1, 4 by 4 by 4 ft., and Nos. 2 and 3 each 2 by 4 by 4 ft. In operation, compartments Nos. 1 and 2 must be filled to a depth of at least 1 ft. with water free from oil or grease, after which all the return from heating coils, engine drips, superheaters, etc., may be turned into compartment No. 1 and discharged in a horizontal direction; this is to prevent excessive agitation of the water in compartment No. 1, which would tend to keep the oil mixed in the water and carry it into compartments 2 and 3 under partition A and over B. The make-up water should also enter compartment 1 first and be regulated by a ball cock to maintain a fixed height at all times. An ample overflow from compartment 1 allows the oil to flow off to waste.

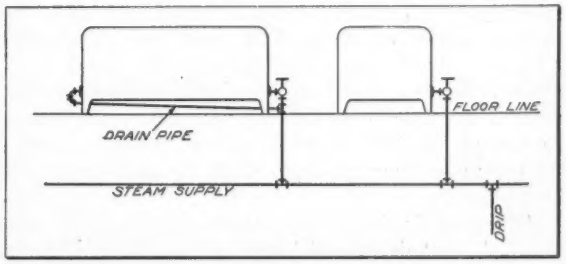
Water entering compartment 1, cold, at a foot or more from the bottom, all oil will rise to the surface and be held back by wall A. Wall B will check all sediment and deposit it at the bottom of compartment 2, and only clean water will be drawn from compartment 3 and fed back to the boilers. Pipes with capped ends are set in the side walls of compartments 2 and 3 close to the bottom to drain the tank when cleaning out. A plank or sheet-iron cover with an 8-in. square spout to atmosphere furnishes vent for steam. Feed water will enter boiler at close to 200 deg.

I operated this heater for about 6 weeks and cut our water bill in half, but I also got oil in my boiler. I later rebuilt the heater and instead of leaving an opening in the partition between compartments 1 and 2, 6 in. from the bottom of the tank, I set in 7 2-in. pipes leading from No. 1 to No. 2 and covered them with cement to make a solid wall and over the ends of these pipes in compartment 1 I placed bags of fine coke picked from the ash pile, and at the present time I have not found any more signs of oil going into the boiler or getting into either compartments 2 or 3, therefore I think the apparatus safe. W. E. CHANDLER.

Radiator Trouble

THE ILLUSTRATION represents the general arrangement of the steam piping for 2 radiators that are operated on a one-pipe system. The radiators, as shown, are located quite close together, and are specially made to fit beneath windows, the sills of which are quite close to the floor.

When the system was first started, everything worked nicely with the exception of the larger radiator. The



PIPING TO RADIATORS

last 6 sections of this were always filled with water, causing more or less water hammer. This radiator is located in the office of the building, and this condition, of course, was objectionable. Apparently the larger radiator was too long to be operated on a one-pipe system.

Several suggestions were offered, the most acceptable being to operate this radiator on a 2-pipe system. This could easily be done, as the arrangement of piping below the floor was such as to make this convenient. Another suggestion was to make 2 radiators of it.

Objections were raised to cutting other holes through the floor, the floor having been laid after all other holes for steam pipes had been provided. To overcome the trouble the engineer of the plant connected a ¼-in. pipe between the back end and the tee, as shown in the illustration. This proved to be a success, the ¼-in. pipe keeps the radiator drained, and the whole of the heating surfaces are now utilized. Note the larger radiator is twice the size of the smaller; the object in having it so is to make the space beneath the window appear more uniform.

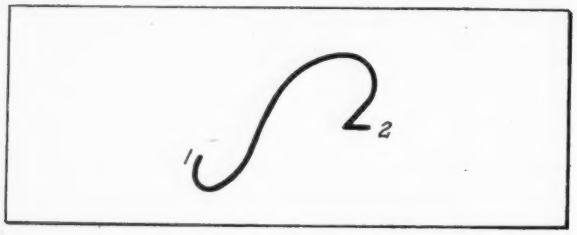
It requires a little more time for the larger radiator to warm up, when steam is first turned on; but the heating effect is much greater, as will be understood by those who are familiar with the principle of steam heating.

KARL HOFFMAN.

Some Boiler Room Troubles

OUR BOILERS are of the horizontal return tubular type the blowoff pipes of which are protected by a baffle wall instead of having sleeves where exposed to the flames. We use an asbestos packed cock and a blowoff valve of the Simplex type. The blowoff of all boilers discharges into one common pipe and our firemen have to blow down every shift as according to Massachusetts state law.

One day, the fireman in my shift came into the engine room and reported that No. 3 blowoff was plugged up and the pipe inside the combustion chamber was red hot. The chief happened to be in at the time, so he went and



TOOL USED TO REMOVE PACKING

looked at it and ordered the fire pulled, and as we are short of boilers, the plant had to shut down as a matter of course. The boilers were cooled off, the one that was plugged was emptied and then the obstruction was removed from the pipe and then the boiler was put on the line again. This took time; it was a good part of a day before we were ready to start up again and I lost the time.

A few weeks later, the fireman reported the same thing. I went down and looked at it, as the chief was not around, and then I opened the valve of No. 3 and also the cock and found there was no sound of water starting. I went to No. 4 and opened it and gave No. 3 pipe a slight blow with a hammer; the obstruction went out and the pipe cooled off with no apparent damage.

Later, I informed the chief of the occurrence, and he told me never to do so again, as he very much preferred to shut down rather than run the risk of bursting the pipe. I can't see where there is any risk, if done carefully, as one end of the pipe is open to the atmosphere; however, I would like to know the opinion of the readers of Practical Engineer on the subject.

I would also ask what they consider the best and easiest way to remove the old packing, both hard and soft, from the Simplex blowoff valve. I removed some in the following manner: I made a tool of the shape shown here and put the end marked 1 down under the rings of packing and with a hammer drove it out by striking at 2. This I did without removing the valve from the line. The packing did not come out very easily and I wondered whether there was an easier way.

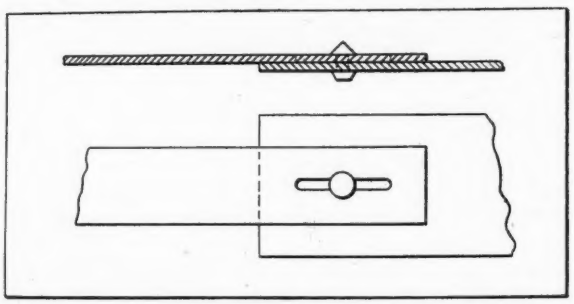
I would also ask how to cut threads on a brass pipe; whether lard oil or without oil is best. Then, how can I prevent the dies from clogging up and stripping the threads, as I seem to have this happen to me quite often on brass pipe?

J. E. K.

Inaccuracy in Calculating Boiler Joints

WE READ in articles, occasionally, of tests made on a new or old boiler to ascertain the relation between the real practical efficiency of the longitudinal seam, and the theoretical strength, be it a lap joint, triple riveted double strap, or quadruple. And we always notice that there exists a difference of from 10 to 50 lb. or more in the proving test.

That there should arise such lack of co-ordination between theory and practice in this particular, surely must awake in our minds a suspicion as to the accuracy of figures; although, fortunately, the rupturing stress almost always occurs that many pounds above the calculated number set, and as long as this is true so much better for safety.



EXAGGERATED CONDITION WHICH EXISTS WHERE RIVETS DO NOT FILL THE HOLES COMPLETELY

This difference, however, must have a cause. It seems that it has never yet attracted the attention of scientists and professors. The notable point I wish to throw light upon is the element of friction between the plates held at the joint; the tenacity at that point occasioned by the enormous grip of the rivets.

The diagram furnishes a good suggestion to illustrate further the characteristic under discussion. Even though rivets are made to fit snugly in their holes, this fact does not nullify the frictional resistance between the plates. Massachusetts, in her famous Rule Book for boiler joints, makes no mention of this, and I doubt if the subject was ever discussed before. It now remains for someone interested to experiment and submit to the readers further information on the subject.

LUKE MARIER.

Successful Kinks From The Plant

For Saving Time, Work and Trouble

Erecting a Boiler

WE HAD a new boiler to erect, and the new breeching was to connect with the old at a place where 2 old boilers had formerly connected. The old breeching is shown at A, Fig. 1, leading to the stack B. A cross section of A is shown in Fig. 2. New breeching was made similar, but through some error, the height, D, Fig. 2, was made about 6 in. greater than the height of the old one. So the bottom rivets near the end, Fig 3, were removed and bottom beat up as shown, making

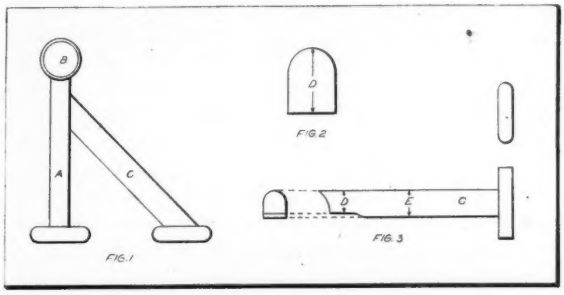


FIG. 1. LAYOUT OF BREECHING
FIG. 2. CROSS SECTION OF BREECHING
FIG. 3. SHOWING HOW SECTIONS WERE MADE TO FIT

the height equal to that of the old breeching. Temporarily assembling this, we marked off the place on the old breeching that had to be cut out. We also found we would have quite a little to cut off the new uptake, which we did with a "ripper." After cutting out the piece from the old breeching, we again brought them together, drilled holes and riveted them.

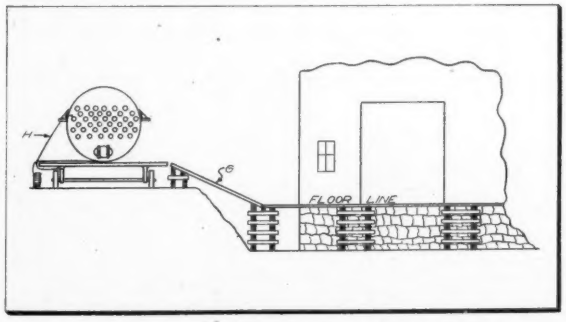


FIG. 5. HOW BOILER WAS UNLOADED FROM CAR

A long timber, on either side of a tubular boiler, bolted to keep from spreading apart, makes a good skid. Use wedge shaped blocks, F, Fig. 4, to keep the timbers from turning under the weight of the boiler.

Mix the fire clay quite thin when laying fire brick and dip the brick in. It is well to rub the brick together dry before dipping; this will remove any projections and permit the brick to lie closer together.

If a bridge wall is built leaving a 2-in. opening at either end, between it and the wall, any expansion which may occur will not affect the wall. The openings themselves will fill up with ashes.

We installed some 66-in. boilers and Fig. 5 shows how they were unloaded from the car. The railroad track was located along the end of the building, and at a few feet higher level than the boiler room floor; this in turn was about 4 ft. higher than the ground. The car was blocked so it would not rock or move and tim-

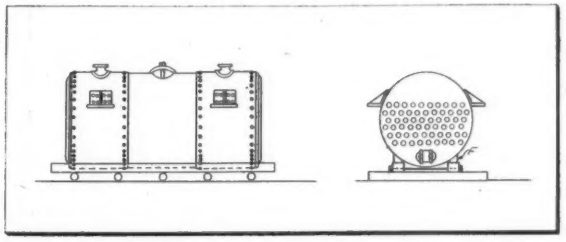


FIG. 4. METHOD OF PLACING BOILERS ON SKIDS

bers, G, used for runways, laid upon cribbing. An end of a long heavy rope, H, was fastened to the car, the other end passed around the boiler, underneath, and snubbed to a car stake. We rolled the boiler down the incline, holding it back by the rope.

Figures 6 and 7 show 2 different ways of riveting sections of smokestack. Each method has its advocates. Which is the better way?

Smokestacks are shipped in sections, and the erector must rivet them together. Sometimes considerable

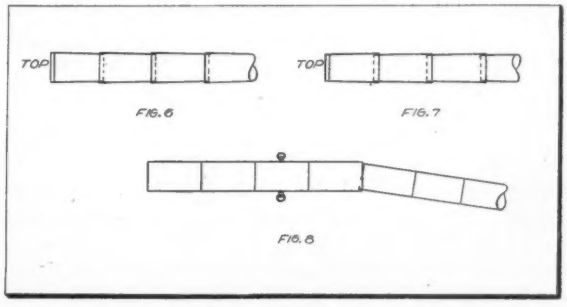


FIG. 6. METHOD OF FITTING STACK SECTIONS
FIG. 7. ANOTHER METHOD OF FITTING STACK SECTIONS
FIG. 8. SHOWING HOW SECTIONS ARE ENTERED

trouble is experienced in entering one section into the other. If they are entered as in Fig. 8 and a few holes matched, small bolts can be used to hold the 2 pieces together. The stack can then be gradually brought into line, meanwhile forcing the one section into the

other. After all the holes are in line, and the stack straight, they can be riveted.

The guy wires are attached to the stack before it is raised and their length is found as follows: Measure the distance from the ground to the eyebolt in the stack, and square this amount. Then measure distance from base of stack to the stake to which the guy wire will be fastened. Square this and add the 2. Extract the square root of the sum and the answer is the distance from the eyebolt to the stake in the ground. Add a few feet for the fastenings, and sag in the cable. All kinks should be removed from the wire.

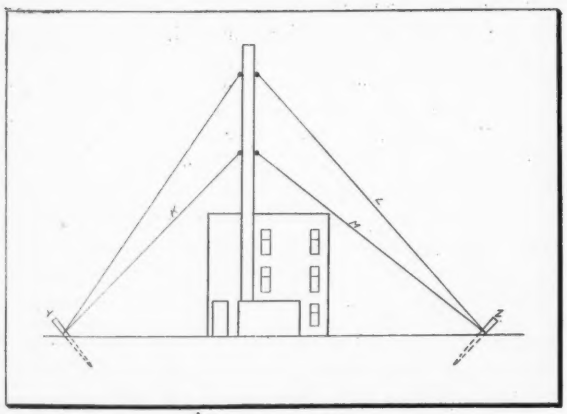


FIG. 9. STACK IN POSITION; LENGTH OF GUY WIRE IS FOUND BY FINDING LENGTH OF HYPOTENUSE

As an example, in Fig. 9, the distance from the ground to the upper eyebolt we will call 50 ft.

Then $50^2 = 50 \times 50 = 2500$.

Distance from stake Y to base of stack is 80 ft.

Then $80^2 = 80 \times 80 = 6400$.

$2500 + 6400 = 8900$. $\sqrt{8900} = 94.3+$.

We have 94.3+ ft., the distance from stake Y to the upper eyebolt in the stack. But as we need a longer piece of wire than this, on account of the extra length required for the fastenings and sag we had better cut off 100 ft. of cable. This is the old rule, the square of the hypotenuse of a right-angled triangle is equal to the sum of the squares of the other 2 sides.

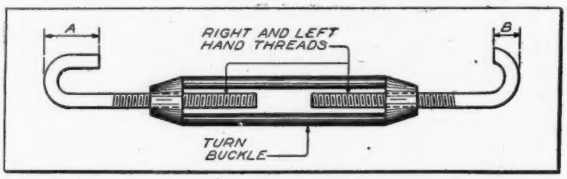
TOM JONES.

Tool for Removing and Replacing Link Belt

WITH REFERENCE to the sketch by S. G., page 1169, Dec. 1 issue, showing a tool for applying link belt and sprocket chain, I submit herewith a sketch of another tool which I have used for a number of years past, for similar purposes, and have found very convenient, particularly in close quarters. Its use is convenient when putting new links in detachable chain, and in bringing the hole in line when putting the bolt or pin in coupling links.

One place in which this can be used to particular advantage is in the case of bucket elevators when these are enclosed with round and square leg steel casings, and whether the buckets are arranged single strand, double strand, or centrally hung. It can also be used to good advantage when renewing the pins and bushings of bushed chains.

In cases where attachments are of such shape as to interfere with the turn buckle, the threaded hooks may be made off-set. The distance B should be less than ½ of A, although this is determined to a greater or less degree by the kind of chain to which the tool is applied. With ordinary link belt, the hook, A, should be about the length of the space in a link. This can be entered at any angle. Then, by pushing the tool ahead or drawing it back, the hook, B, will enter a link. If the



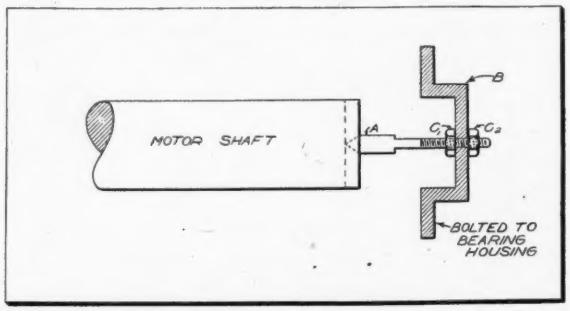
TOOL FOR APPLYING LINK BELT AND SPROCKET CHAIN

hook, B, were the same length as hook A, it is plain that hook B could not enter a link after hook A is in place. This makes it convenient in that after hook A is in place, the left hand can be used to hold hook B, meanwhile operating the turn buckle with the right hand until both hooks bear on the links. When the chain is drawn to the required degree of tightness, both hands are free for use in removing and replacing link, or otherwise.

KARL HOFFMAN.

End Play Preventive

THE ACCOMPANYING illustration shows an easily made arrangement to prevent the end motion of shafts. I made and used this to my entire satisfaction and found that end play which could in no other way be remedied was at once stopped.



METHOD OF APPLYING SPINDLE

A spindle, A, is made, the size of which depends upon the size and position of the shaft. C_1 and C_2 show lock nuts used to adjust the spindle, while B is an iron bracket bolted to the bearing housing. While not absolutely necessary, it is advisable to apply a little oil occasionally between the spindle and the center hole of the shaft.

GEORGE L. MACLEAN.

TESTS CONDUCTED by the leading railways of France are said to have shown that fogs may be dispelled by means of electric waves. A radiating apparatus embodying the principles of wireless is used, and it is claimed that in certain instances the atmosphere has been cleared for distances of 600 ft. in front of the antenna.—Popular Mechanics.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Pump and Engine Questions

WHAT IS combustion?

2. If a pop safety valve is set to blow at 100 lb., what adjustments would you make to cause it to blow at 60 lb.?

3. What may be the cause of a duplex pump reversing before reaching the end of its stroke?

4. Give a practical method of finding piston clearance at each end of the cylinder.

5. If a crankpin is badly worn, where would you place the engine when keying up?

6. What part of an engine requires the most attention? Why?

7. How would you determine whether or not a crosshead is in line? F. S.

A. Combustion is a chemical union between combustible elements in fuel and a supporter of combustion. This supporter of combustion usually is the oxygen contained in the atmosphere.

The principal fuels are coal, wood, gas and oil. The chief combustible constituents of these fuels are carbon and hydrogen, but their characteristics and modes of entering into combustion are very different.

The carbon unites to form carbon dioxide, the hydrogen to water or steam, sulphur to sulphuric acid, and any other elements, commonly called impurities, to their respective oxides or remain as ash.

2. To lower the pressure at which a pop safety valve is set to blow, the tension of the spring should be lessened if the desired change does not exceed 5 lb. If more than this is desired, it is best to replace the tension spring with one of the right tension; in your case, a new spring would be the proper way of adjusting.

3. A duplex pump will reverse before the pistons have made a full stroke if there is not enough lost motion in the valve gear.

4. The piston clearance at each end of the cylinder may be found by disconnecting the rod from either the crank or crosshead, pushing the piston against one head, marking the guide at the end of the crosshead, then pushing it against the other head and again marking the guide. These marks give the striking points. If the rod is now connected and the crank placed on the center, the distance from the end of the crosshead to the nearest mark will give the piston clearance for that end of the cylinder. With the crank on the other center, the clearance for the other end may be found in the same way.

If the volumetric clearance is desired, place the crank on the center and fill the clearance space with water to the face of the inlet valve. The water required will give the volumetric clearance, provided that neither the exhaust valve nor the piston leak. To do this, weigh a quantity of water more than enough to fill the clearance and after the clearance space is filled, weigh the remainder; the difference in the 2 weights will give the weight of water required, which can be reduced to cubic inches by dividing the weight in pounds by 0.0361.

5. The point of greatest wear on a crankpin is on that side in line with the connecting rod when the crankpin is at a point about 45 deg. past the center, so that the best place in which to key up is at a point about 90 deg. from this point, or about 45 deg. back of the center.

6. All the working parts of an engine require intelligent attention, so it is hardly possible to single out any one or more parts that need more attention than other parts. Of course, the bearings and pins should be given great care; but the valve gear or the condition of the valves and cylinder are also important points to watch. The bearings and pins must be in good condition to insure continuity of operation and reduce friction and the condition of the cylinder and valve operating devices must be equally as good to insure economy.

7. The crosshead is in line when the piston rod is parallel to the guides at all points of the stroke.

R. E. T.

Babbiting Crankpin Brasses

AS I HAVE not been having very good luck babbiting crankpin brasses, I thought I would write to you for the proper way to go about it and the proper kind of babbit to use. Any information will be greatly appreciated.

C. W. L.

A. No doubt you appreciate the fact that babbiting crankpin boxes is like many other tasks,—the method of procedure depends a great deal on the nature of the work to be accomplished, and the facilities for doing the work under existing conditions. I will offer a few suggestions suitable for the average conditions, and trust that you will be able to accomplish the desired results with their assistance.

We will assume the engine a small one and of side crank drive, and that the pin has not been worn out of round. Before dismantling the box, scribe around the collar, making a heavy mark on the brass box for future reference, as will be shown later.

In order to make a satisfactory job of any kind of babbiting, care must be taken to avoid "cold shots," by warming the pin and boxes, which insures rapid flow of the molten metal. Heat a piece of metal that will easily slip over the pin and leave it there while you do the other necessary work. If no rings or castings are at hand, heat a solid chunk of iron, set it on an iron pedestal under the crankpin, and leave it there till ready to assemble the box.

While this heating up process is going on, remove the old babbit by heating over a forge on a thin plate, to conduct the molten metal to one side, or with one or 2 gasoline torches. If using an open fire to melt the babbit, take care not to burn the boxes.

Note whether the boxes are equipped with the necessary anchors to hold the new babbit. Also whether they are free from sand. If the anchors are not sufficient to hold the new babbit in place properly, drill holes, say with a ¼ or ⅜-in. drill at a slight angle in opposite directions in the boxes, and countersink them slightly to prevent breaking off, which sometimes happens if the corner is sharp.

Plug up any oilholes in the pin with a wooden plug driven in and the head covered with putty. This combination is easily removed with a gimlet afterward. Cover the pin with a light coat of black lead mixed with cup grease.

With the pan and boxes as warm as can be handled, assemble the bearing on the pin, using liners, say ⅛ in. thick and wide enough to extend into the pin so that the 2 halves of the box will not be in one solid piece The top liner can be arranged with holes to pour through or, if the strap has a hole for the oil cup, this can be used as a pour hole, and the metal afterwards bored out with a drill.

Take care in this operation that the coating of black lead is not rubbed off, which may be avoided by blocking up the connecting rod with a suitable stick. Then revolve the shaft, or move the crosshead as required, till the collar on the pin coincides with the scribed mark on the brasses. Draw up snug on the key or wedges, and be sure that the brasses fit in the strap properly.

Divide up the clearance between the collar on the pin, and the crank disk. When all is well, pour the babbit, making it all in one pour, or if the job is too big, or the ladles too small, have the second ladle ready to pour as soon as the first is empty, so there will be no "break" in the babbit.

Babbit is one of the many things in this world that few people are acquainted with, although in common use. Speeds and pressures are the principal factors entering into the use of babbit and the manner of mixing the several ingredients also has much to do with the lasting qualities.

Speaking in a general way, there are 4 principal grades of babbit, numbered consecutively: No. 1, for pin bearings and also for bottom and side boxes of main bearings, bottom shoes, etc.; No. 2, for same work when the duty is not too severe; No. 3, for top boxes of main bearings, top shoes, slow speed line shafting, etc.; No. 4, used principally for very slow, light bearings, metallic packing rings, etc.

Babbit for pins or bearings should not have a melting point lower than 550 to 600 deg. F., and should hold its shape well up to that. There are several excellent bearing metals of several different compositions advertised in Practical Engineer, and their goods have a wide sale and are generally satisfactory.

To sum up other possible conditions: If the engine is a center crank, or the bearing large, it is best to babbit it around a mandrel slightly smaller than the pin, and after pening it with a ball-pene hammer, assemble the 2 halves in the same relative position they have on the pin, and bore them to size.

If it is a strap end rod, wedge the boxes in it and clamp on the face plate of mill or lathe. If a solid end rod, use strap iron and bolts to hold boxes while boring.

After the boxes are babbited and bored, scrape to a fit on the pin, and relieve each half about an inch or more from the joint to prevent binding of the pin in case of slight heating. Cut generous oil grooves in both boxes, in such a manner that the oil will be continually worked toward the middle of the pin in preference to toward the ends, but do not have the grooves too wide, as this cuts down the bearing surface.

If you have time, after assembling the bearing, key up snug and run the engine slowly, watching carefully, and as soon as it begins to warm up, stop and scrape off the high spots. If necessary and convenient, repeat, and you will have a fine bearing. GEO. H. WALLACE.

Refrigerator Temperatures

CAN YOU let me know the temperature best suited for the family refrigerator? Also the highest and the lowest temperature permissible for the preservation of food? J. R. F.

A. The temperature that is considered best on the average is 34 deg. F., although I imagine comparatively few refrigerators of the ordinary kind hold a temperature as low as this. I think that usually the temperature is around 40.

So far as the high and low temperatures for this purpose are concerned, I am giving you a table of the high and low temperatures for different materials, which comes as near answering the question as anything I know of.

	High Deg. F.	Low Deg. F.
Fruit	40	34
Vegetables	38	32
Fish	38	30
Dairy Products	36	32
Meats	40	30

A. L. R.

Advantages of Superheated Steam

AT THE bottom of page 94, of the Jan. 1 issue, is a short article stating that for heating, saturated steam is better than superheated steam, hence it is better to make steam at low pressure than to use high pressure steam through a reducing valve. I have often heard it stated that the exhaust from an engine works better in a heating system than live steam from a high pressure boiler which has passed through a reducing valve, and which is, of course, superheated as the pressure is reduced, but the article referred to is the first time I have seen this in print.

I shall be glad if you will advise me in regard to any theories which will explain why this is true.

H. H. W.

A. The reason that the exhaust steam from an engine or low-pressure steam from a boiler works better than that through a reducing valve, is simply because

of the fact that heat is conducted better through a moist vapor than through a gas, and also, the walls of a pipe can take up heat faster if they have close contact with a film of moisture than they can when perfectly dry.

In the case of the exhaust steam from an engine, we have the additional effect of a series of intermittent puffs, which tends to keep all the steam in the system in circulation,—perhaps in a rather swirling effect than in a straight flow,—so that the steam in the middle of the pipe is given better chance to move around and come in contact with the pipe walls than where the flow is steady.

The superheated steam is practically a gas, and therefore has a lower conducting power for heat than the saturated or wet steam, and also it prevents the formation of any moisture on the surfaces of the pipe.

A. L. R.

Proper Brine Cooler Valves

COULD I obtain better results from a shell brine cooler in an ice tank by using a needle point expansion valve instead of a 1-in. flat disc angle valve?

SUBSCRIBER.

A. No better results will be obtained by the use of a needle point valve. In the first place, I do not believe that the needle point valve is made as large as 1 in. This style of valve is used for feeding ammonia to coils where close regulation is required. In short coils or in coils in extremely cold rooms, very close regulation is necessary or the coils will be flooded and cause liquid to be drawn into the compressor.

The shell type brine cooler as installed in ice tanks is built on the so-called flooded system and the amount of ammonia fed into it can easily be properly handled with a regular globe or angle valve. The accumulator will take care of any excess feed within a reasonable amount.

It is best to leave the cooler connected up as it is with the 1-in. angle valve, and by a little practice and by noting results, the proper amount of opening will soon be learned.

A. G. SOLOMON.

Vacuum Variations

I WOULD like to know the possible obtainable vacuum on a surface condenser when the outside barometric reading is 28.5 in. Does the number of inches of vacuum decrease as the outside air pressure decreases? I would like to have an example figured out for me.

I am getting 27½ in. of vacuum on a surface condenser and wonder if that is as much as I can get at this altitude of 1100 ft.

H. L. M.

A. The vacuum obtainable depends, of course, on the effectiveness of the condenser as well as on the barometric pressure; but the obtainable vacuum decreases as the barometric pressure decreases.

Obviously, where your barometric pressure is 28.5, it would be impossible to get a 29-in. vacuum, although this is not infrequently done with a 30-in. barometer. Ordinarily, 1 in. less than barometric pressure is as well as can be done; although in some instances where the units installed are large enough to make it worth while, a vacuum within ½ in. of barometric pressure has been secured.

The barometric pressure varies, as you are aware, with the weather, through a small range, and it varies also with the altitude, but not exactly in direct proportion. For instance, with a barometer of 30 in. at sea level, 29 in. would be 890 ft., 28 in., 1812; 27 in., 2767; 26 in., 3758; 25 in., 4787; 24 in., 5859; 23 in., 6977; 22 in., 8144; 21 in., 9366; 20 in., 10,648.

Your pressure of 28.5 corresponds to an altitude of 1347 ft., at a temperature of 32 deg. F.

A. L. R.

Pump Problem

HOW HIGH will a pump with an 8-in. steam piston and a 6-in. plunger force water with 80 lb. of steam?

G. H. N.

A. The rule is, that the water pressure times the area of the water piston is equal to the steam pressure times the area of the steam piston.

Then $X \times (6^2 \times 0.7854) = 80 \times (8^2 \times 0.7854)$;

$X \times 36 = 80 \times 64$

$X = 80 \times 64 \div 36$

$X = 142.2$ = water pressure per sq. in.

0.433 = pressure exerted by 1 ft. head.

Then $142.2 \div 0.433 = 328$ = head in feet.

This is neglecting friction, so allowing 10 per cent for friction, we would have a head of $328 - 32.8 = 296$ ft. nearly = height to which the pump would force water.

R. E. T.

Rolling and Beading Tubes

IN TREATING leaky flues, is it best to bead the ends first, or roll up and then bead?

E. W. M.

A. It is always advisable to roll in the tubes before beading over. The rolling will sometimes stretch the tube a little lengthwise, and if it does this after the tube has been beaded over, the beading will be forced away from the tube sheet, thus increasing the chance for leakage.

A. L. R.

Engine Problem

KINDLY tell me the number of expansions in a Corliss engine 20 by 40 by 42-in., cutting off at ¼ stroke in each cylinder.

I. P. I.

A. The number of expansions which take place in your compound engine are 16.

This is calculated as follows: The volume of high-pressure cylinder to cutoff equals 3300 cu. in. The volume of low-pressure cylinder at release equals 52,750 cu. in.; $52{,}750 \div 3300 = 16$, number of expansions.

R. E. T.

Beaded or Rolled Tubes

THERE APPEARS to be quite a difference of opinion as to whether the tubes in Stirling boilers are beaded or rolled and flared at the ends, as required by the Massachusetts boiler rules.

I have failed to find a Stirling boiler tube beaded, though I think there are some in the top of the mud drum in some boilers on account of air leaks existing at that particular place. I would like to hear from some reader who has found tubes beaded in Stirling boilers, and the reason for this.

M. W. C.

Problems For Discussion By Readers

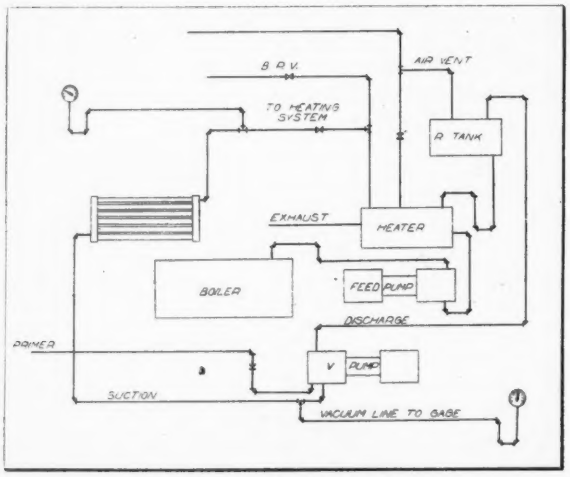
What Would You Do If You Had These Conditions To Meet?

Tarnished Cylinder Heads

THE CYLINDER heads on a pump in our plant become very hot and as a result I am unable to keep them polished. Twenty-four hours after polishing they turn blue. I wish some of the readers could tell me how to prevent this. J. L. S.

Trouble With Heating System

HERE IS an outline of a heating system that has given me some trouble; on 1 or 2 occasions it seems no returns would reach the vacuum pump. The discharge pipe was ice cold, even with the cold water primer closed. I found in going over the lines the Cryer valves were taken out, and I could only get 5 in. of vacuum. Would that cause the pump to draw air from the heater due to the back pressure opening and closing? I also found the pump required packing and new valves. These I replaced, but found on starting up that instead of showing



HEATING SYSTEM LAYOUT

vacuum, the gage registered 10 lb. pressure on the negative side. I suppose the spring is out of order, but would the fact of the Cryer valves being out cause the pump to suck air? We carry 4 or 5 lb. back pressure on the heating system. Don't you think there is something wrong? I imagine 1 or 2 lb. should do, although it's quite a large factory and some of the windows are bad. There are 4 drying boxes for drying wood; these boxes are 4½ ft. under the vacuum pump. The return is connected to the heating system returns from the house at the pump; this return line is 2½ in. and 2 big holes are eaten away out of this pipe. We are replacing this line. I claim the vacuum pump can not get the returns from these boxes as the water is too hot and the boxes too low under the pump. Is this too much of a lift for the pump, or is it the presence of the steam that forces the returns to the pump? We have 2 feed pumps, one a packed plunger and one a solid plunger; the packed plunger pump has been working ever since I have been here, but last week the packing gave out and while replacing the packing I put the other pump to work. It made an awful noise on the long arm side, when the plunger would reach the end of the stroke it would slam back, causing the feed pipe to rattle terribly.

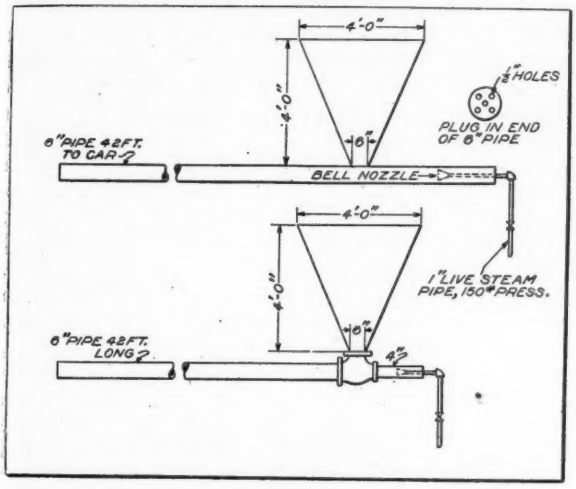
After I got the packed pump into shape, I went to work on the solid piston pump. I found on the long arm side the steam follower has a pin cast on it and a hole in the piston to correspond. It appears that in putting back the follower somebody did not put the pin into the hole, leaving the follower ¼ in. away from piston, allowing steam to pass through. The pin was flattened, I filed it round and put it back, putting pin in hole, bringing follower up against piston. This improved conditions somewhat, but still the long arm plunger slammed back, the valves were well set. I shortened the valve stem on long arm side 2 turns and lengthened 2 turns on short arm side. This caused the back slam and the awful noise in feed line to disappear. The stroke on long arm side is a trifle short; but otherwise seems to work quite smoothly, but does not throw enough water to feed the boilers. It's the same size as the packed pump. I looked at the plungers; there seems about ⅛ in. clearance between top of plunger and sleeve, with plunger resting on bottom of sleeve. Is that too much or are they worn? R. L.

Unsuccessful Ash Blower

THE ACCOMPANYING sketch appeared in the Aug. 15, 1914, issue, page 837, describing an economical way of handling ashes, which we have tried without success. Will someone who is successfully blowing cinders with high pressure tell us what the trouble is?

We have a bucket elevator to carry cinders from the basement of the boiler room to a screw conveyor delivering the cinders to the rear of the building, and as we could not have a track at this point, we have to drop the cinders on a platform and wheel them to the car. We cut a hole in a 6-in. pipe and built a hopper 4 ft. high and 4 ft. wide above and secured it to the pipe terminating at the bottom with a 6 by 6-in. opening. Entering the end of the 6-in. pipe is a 1-in. steam line with a bell nozzle, the end of which is 18 in. from the hopper opening. The 6-in. pipe is 42 ft. long and nearly level. The elevator was started and steam turned on, but the cinders would not blow through, as

the condensation of steam would wet the fine ash, completely plugging the 6-in. pipe line, causing the steam to blow out at the hopper. Our steam pressure is 150 lb. We have also tried several other arrangements—closed the air opening in the flange through which the steam pipe enters the 6-in. pipe, advanced the nozzle



ASH BLOWING ARRANGEMENTS WHICH PROVED UNSUCCESSFUL

gradually up to and even beyond the hopper opening and finally used a 6 by 6 by 4-in. tee at the junction of the ejector pipe with a 12-in. piece of 4-in. pipe between the tee and the 1-in. steam pipe. This was all to no purpose.

E. L. HUDSON.

Boiler Dimensions

IN REGARD to the method of measuring the length of boilers of different types, I have before me specifications of a number of different types of boilers. In the water-tube boilers of the horizontal type, the drum dimensions

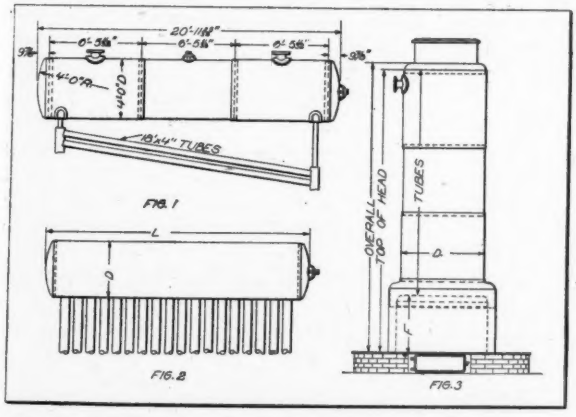


FIG. 1. DIMENSIONS OF HORIZONTAL WATER-TUBE BOILER
FIG. 2. DIMENSIONS USED IN DESCRIPTION OF STIRLING DRUM
FIG. 3. DIMENSIONS USED IN SPECIFICATION OF VERTICAL BOILER

are measured as shown in Fig. 1. The overall length being given as 20 ft. 11¾ in., and the drum is called 21 ft., the specifications state: "……shall have 100 tubes 4 in. in diameter by 18 ft. long, ……one drum 48 in. in diameter by 21 ft. long, ……"

The measurements shown on the drawings are outside to outside of head.

Figure 2 is a Stirling drum and the dimensions are also given as outside to outside of bulge, or the overall length of the drum.

Figure 3 is a Manning boiler, the measurements of which are given from floor line to top of smoke box, floor line to top of head, length of tube and height of crown sheet from floor line. In all boilers, the diameter is taken from the inside of the outside course, as shown in the drawings.

Figure 4 shows a full front tubular boiler called 60 in. by 16 ft. The inside diameter of the outside course is 60 in., and the length of tubes outside to outside is 16 ft.

Figure 5 shows a half front 60-in. by 16-ft. tubular in which the overall length is given as 17 ft. 5 in., tubes 16 ft. and uptake 17 in. In showing the lengths of

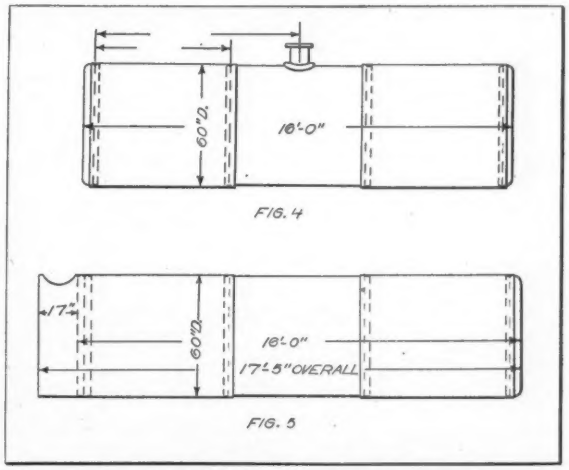


FIG. 4. FULL FRONT TUBULAR BOILER
FIG. 5. HALF FRONT TUBULAR BOILER

the several parts, the measurements are usually taken from center to center of rivets as in Fig. 1. Boilers are being built in so many different shapes and sizes for the same capacity, that as a rule in all except possibly the tubular boilers, all the principal dimensions are given as overall length of drums, length of tubes, diameter of drum, height of water leg, and other individual features.

J. C. HAWKINS.

IN ANSWER to G. A. W., Stirling, Heine and B. & W. boilers are measured from the outside of one head to the outside of the other.

By a fire-tube boiler I suppose is meant a return tubular boiler. They are measured the same as the drums on water-tube boilers.

An upright boiler is measured from bottom of water leg to the top tube sheet. A locomotive boiler is measured from rear tube sheet to front sheet of fire-box.

C. M.

Test Gage Connection

MR. BLAKE'S steam gage on page 1174, Dec. 1 issue, is not right, in my opinion, as the connections for the inspector's test gage should be taken from the pipe to the steam gage, not through the steam gage as shown.

C. M.

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The "Furnace Variable"

Standardization of steam boiler ratings has been, is, and will continue to be, the subject of much well deserved investigation. Recommendations will be made and laws and rules laid down—all with the object in view of arriving at a standard for boiler ratings that will be founded on true boiler capacity. As in the past, this will be based on some relationship between grate area and boiler heating surface. Rates of fuel consumption may be specified and it is quite possible that some general classifications of possible fuels for use at specified ratings will be decided upon. But what about the "furnace variable"? Fixing a standard here would promise to be exceedingly difficult, if not impossible, particularly when boilers are being operated at continually higher ratings.

The efficient "furnace variable," meaning the depth, height or distance of the grate from the boiler, upon which the furnace volume depends, differs for each grade of fuel and for every rate of fuel consumption. This is startlingly emphasized in the cases of 4 large and economically operated steam plants, plants in which the boiler units are quite similar, where the boilers are driven at high ratings and where steam is generated efficiently and at exceptionally low cost. In one case, the distance from the grates to the boiler is about 8 ft.; in another, 10 ft. In one of the plants the distance is several inches over 13 ft., and in the fourth plant the products of combustion journey nearly 30 ft. before they reach the boiler heating surfaces. These are all large boilers, but almost as much difference in settings may be found in plants operating on comparatively small boilers.

The "furnace variable" has been carefully considered in each of these 4 stations—the best procurable engineering talent has been employed in designing the settings in each case and no expense spared to secure the best results—and it may be assumed that the highest boiler efficiency is realized in each case. The grade of fuel employed in each plant is not the same nor are the boilers all operated at the same degree of rating, it is true, but a variation of 300 per cent in "furnace variable" would appear to be more than could be cared for by standard equipment. The "furnace variable" has remained a problem for the engineer—one that requires the knowledge gained from and diverse experience supplemented by careful tests and experiments, but there seems to be no good reason why our experiment stations cannot be of great aid in the solution of this problem.

Complicated as this important consideration must be, there are a few general rules that Practical Engineer for a number of years has been advocating as a guide in correctly proportioning the "furnace variable," and it seems wise again to call attention to these rules. This dimension should be such that no visible flame reaches the boiler heating surface when the boiler is being driven at its highest operating rating when fired on the longest flame fuel that may be employed in the plant. When operating the boiler at less than the maximum rating, the distance from the grate to the heating surfaces will be greater than necessary, but any decreased efficiency that may result from such design, when working under the less exacting conditions, will not be as serious as the losses that would be brought about

during periods of heavy demand if combustion should be visibly incomplete, when visible flame comes in contact with heating surfaces.

Flame is only visible while combustion is taking place and visible flame in contact with the comparatively cool heating surfaces of the boiler means the arresting of combustion with the accompanying deposit of soot on the heating surfaces, incomplete combustion of the carbon constituent of the fuel and unnecessarily elevated temperature of the exhaust flue gases.

A "furnace variable" greater than necessary also invites heat losses, it is true, but they consist simply in radiation losses and those due to the leakage of air into the combustion chamber through the boiler setting, etc. Losses which, if they cannot be entirely eliminated, can be easily minimized and kept down to below those that must occur if the gases strike the heating surfaces while still containing combustible and unconsumed constituents.

High boiler settings cannot be too strongly recommended, boiler manufacturers' standards should advisably be ignored in many instances and the limitations to headroom so frequently arbitrarily fixed by the architect of the building must be energetically condemned.

Have Your Boiler Water Tested

One reason why engineers do not send their boiler water away for analysis is the "trouble" connected with hunting for a large bottle, the trouble of crating the bottle, and shipping it. We prefer to sit in a rocking chair and let others do our work, or, it is not done at all. In many instances it is not done at all. The same old boiler water is still used and we managed to scrape along some way or other, but we don't actually KNOW whether or not we are handling our feed water in the right way. Perhaps we could remove a large per cent of the impurities before the boiler is reached if we had the proper equipment named by specialists who analyzed the water.

Very well, then. If you hate to do the dirty work of hunting a bottle, all you need to do nowadays is to write to almost any one of the regular feed water analysts for a demijohn all fixed and ready for the water. Your part is to pour in the water and ship it back. What more could the experts do for you? After all, it's the logical way, and it's the least expensive way when you consider time that would otherwise be spent in searching for and packing your own bottle. The specialists will send you something that is just right.

News Notes

KERR TURBINE Co., Wellsville, N. Y., announces that its New York office, now in charge of the newly appointed District Manager, Benjamin G. Fernald, will remain in the Singer Building but is being removed to Room No. 801 in the Annex—No. 95 Liberty St. Lawrence G. Hanmer will continue to be associated with the New York office and arrangements have been made for prompt and effective attention to all inquiries.

H. H. LINDEMUTH, York, Pa., who has withdrawn from the York Engineering Co., Inc., as President, and all other operating connections, will re-enter the business with a new company under the name of the "Lindemuth Engineering Co." (to be incorporated later on), with main office in the John Hartman Building, equipment including the most modern facilities.

H. H. SEABROOK, formerly District Manager of the Westinghouse Elec. & Mfg. Co. in Baltimore, assumes the position of District Manager in Philadelphia, and due to the consolidation of territories, the Philadelphia office will hereafter embrace that previously covered by the Philadelphia and Baltimore offices. Mr. Seabrook succeeds J. J. Gibson, who becomes Manager of the Detail & Supply Department at East Pittsburgh.

Mr. Seabrook was graduated from Lehigh University in 1897. His first business experience was with Thomas A. Edison, for whom he worked on magnetic ore reduction. Later, he became associated with the New York Telephone Co. in New York City as foreman of underground cable work, afterward assuming the position of electrician for the Waldorf Astoria Hotel in New York City.

In 1899, he entered the shops of the Westinghouse Elec. & Mfg. Co., where for about a year he worked in the Erecting Department. In 1900, he was transferred as a salesman to the Washington office, where he continued until 1902, when the Washington office was transferred to Baltimore. During his connection with the Washington and Baltimore offices, Mr. Seabrook built up a wide circle of friends who will be glad to learn of the enlargement of his duties.

JOSEPH T. RYERSON & SON, of Chicago, are seeking a trade name for a line of tool steel and are offering prizes of $325 in cash and books for the 3 most satisfactory suggestions. Particulars can be obtained from them. The contest closes April 15.

THE CEMENT-GUN CONSTRUCTION Co., of Chicago, Ill., has been given the contract to encase all the structural steel work on the new power house now being erected by The Ford Motor Co. at its Detroit factory to protect the steel against damage by fire or corrosion.

U. S. CIVIL SERVICE COMMISSION announces an examination for ordnance draftsman, on Feb. 3 and 4, 1915, to fill vacancies in any U. S. navy yard or naval establishment or in the Department at Washington, D. C., at entrance salaries ranging from $3.28 to $5.04 a day. Age, 18 yr. or over on the date of the examination. Each applicant will be required to submit to the examiner on the day of the examination an unmounted photograph of himself taken within 2 yr. Apply for Form 1312.

Correction Note

OUR ATTENTION has been called to a typographical error which appeared in the Jan. 1 issue. On page 21, the formula for finding the area of a segment of a circle should be $\frac{4H^2}{3}\sqrt{\frac{2R}{H}} - 0.608$ instead of the form in which it was printed. Also on page 63 of the same issue, the captions under the cuts should be transposed as the regulator shown to the left is the Burrows and that to the right the Locke.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Powell Automatic Stop Valves

WHERE more than one boiler is in use, the value of an automatic stop valve cannot be reckoned too highly if it eliminates the possibility of steam escaping into a boiler which might be unexpectedly out of commission or shut down for repairs. A feature in the operation of such a valve is the prevention of danger to workmen when engaged inside a boiler for cleaning or the insertion of new tubes.

In the Powell "White Star" automatic stop valve, illustrated herewith, outside screw stem and yoke top are provided; all parts throughout are of an extra heavy pattern and good for steam working pressure up to 250 lb. They are made either screwed or flanged ends.

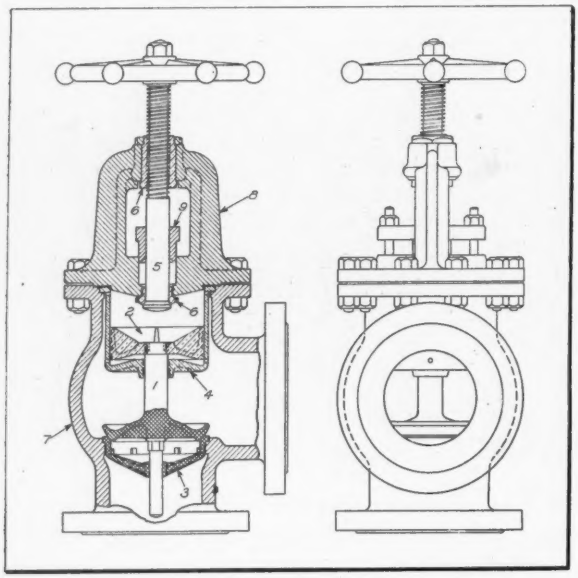


FIG. 1. POWELL WHITE STAR AUTOMATIC STOP VALVE

The body, 7, and yoke, 8, are cast of a close-grained iron of high tensile strength, connected together by steel bolts and nuts of sufficient number to bind firmly the flanged faces together. The gasket is housed in a recess in the body back neck flange under the projecting top of the dashpot, 4, and is held firmly in place by the compression given by the bolts and nuts when assembled.

The valve disc, 1, is cast of Powellium metal (special nickel composition) to resist the corrosive action of steam, to which is attached the plunger, 2, cast of a hard steam bronze composition. The disc and plunger are made with only one screw part and permanently fastened with 2 set screws, making it practically one solid piece from top to bottom, which is guided on both the upper and lower end. The dashpot, 4, is cast of a hard steam bronze composition, fits snugly in the valve body. This feature will be appreciated when taking the valve apart, no danger in getting the parts out of line when re-assembling. The rim of the upper part of the disc-plunger, 2, is grooved, so that it may work with a minimum of friction, and respond readily to any variation in the pressure. The dashpot, 4, has 2 vent holes at top and bottom, to allow the draining of the condensed water that may collect therein. The lift of the disc is equal to the depth of the dashpot, insuring a full opening of the valve. The height of lift is regulated as desired by raising or lowering screw stem 5, which is cast of a hard steam bronze composition and machine threaded.

The seat ring, 3, is cast of Powellium metal with a guide for the lower part of the valve disc, holding it

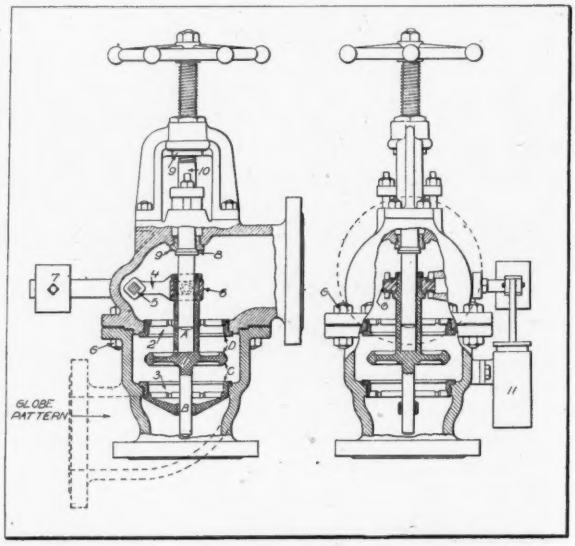


FIG. 2. POWELL WHITE STAR DOUBLE AUTOMATIC STOP VALVE

perpendicular to the seat at all time. The expansion of the seat and body is uniform, the composition of the seat being made with that in view.

When necessary, the seat can be readily renewed by inserting a flat tool between the lugs projecting from the inner circle and unscrewing.

This valve will automatically shut off the flow of steam from header to boiler in case a tube should burst. It can be opened only by the pressure in the boiler, thus acting as an automatic equalizing valve between the boilers of a battery, and it is impossible accidentally to turn steam into the boiler when it is being cleaned. The valve disc is cushioned by the dashpot, 4, to prevent chattering.

The dashpot and plunger being made of bronze, prevent sticking through corrosion of these parts. This valve should always be installed in a vertical position and can be used as an ordinary stop valve by screwing down the stem onto the disc, but the steam must always be wide open when the valve is in use.

Wherever there are 2 or more boilers connected to a single header, the Powell double automatic stop valve, Fig. 2, is preferable to that described above, as it not only will instantly shut down should the pressure in the boiler to which it is attached suddenly decrease below the pressure in header, but will also close in case of a break in the main steam line. The valve disc is one piece top and bottom, guided at A and B, and has a seat on both sides, C and D. The disc seats at C should anything happen on the boiler end, and on D if there is any trouble in the main steam line.

A fork, 4, is fastened to balancing lever stem and holds disc 1 in position. A collar on the stem permits re-packing of the valve when wide open and under pressure. To prevent the valve from chattering, an oil dashpot chamber, 11, is provided.

The special features of this valve are that it can be readily taken apart by unscrewing the nuts from bolts C and lifting off the upper half of valve, the disc, 1, may be taken out and reground on both surfaces for the upper and lower seats and at the same time giving plenty of room to examine the seats to be sure that they were ground in properly, and the disc is made with a swivel attachment so it can revolve, which prevents it from seating in the same place all the time. The valve derives its action from the flow of steam through the valve and not from a variance in pressure. These valves are manufactured by The Wm. Powell Co., Cincinnati, Ohio.

Inexpensive Excavation by Cleveland Railways Co.

TESTS made on some excavation work done by the Cleveland Railways Co., last summer, indicate that this company is reaping the benefit of its efforts to economize.

In building its 79th St. line, the Railways Co. had to do a considerable amount of excavation for which it employed the electrically driven Thew automatic shovel illustrated herewith.

This shovel is of the horizontal crowding motion type and has several other features of interest. It weighs 13 tons, has a dipper with a capacity of ⅝ cu. yd., and a clearance height over the house, of 12 ft. 2 in. It is mounted on regular car wheels on which it travels on the car tracks, and in addition, is equipped with a set of auxiliary traction wheels, 33 in. in diameter, and 15 in. tread, which permits it to run under its own power over the ground, pavement, or wherever it is desired to take it.

The horizontal dipper crowding motion utilized, is said to be particularly adapted to the application of electric drive because of the ease of control and power demanded. In excavating material with a shovel, it is necessary first to crowd the dipper forward into the material, then to hoist it upward through the material. In this case, the first motion is made horizontally, being obtained as follows:

The dipper is suspended by an adjustable arm, hinged to a carriage or trolley moving horizontally along a suitable trackway. This enables the shifting of the point of rotation for dipper, so that the hoisting force is at all times exerted in the most effective manner, while the crowding force is applied horizontally. The combination of the horizontal trackway and the boom channels results in a structure braced and reinforced to withstand the severe strains which the boom is called upon to endure.

The trolley motion is controlled by a lever. This lever is further connected to a trip rod which is operated automatically when the trolley reaches the limit of its motion in either direction.

The crowding motion enables this type of shovel to be advantageously employed for very shallow excavating operations.

AUTOMATIC SHOVEL AT WORK

The entire motive power for traction, hoisting, and swinging consists of one 20-hp. Westinghouse compound-wound, 550-v., direct-current motor with a starting and reversing control equipment. The motor operates at approximately constant speed, the various motions being controlled through suitable friction and gears.

Current is usually admitted to the shovel through a flexible insulated cable connected to a switch on the truck frame and transmitted through copper rings to brushes suspended from the swinging turntable.

Use of one motor appears to be a particularly desirable feature, for reducing the initial cost, and affording greater flexibility of action in the frequent reversals of the various operating motions; it also means the operation of 3 levers instead of 3 separate controllers, and a gain in time over starting and stopping 3 separate motors. It is distinctly a one-man machine.

The boom is of the jack knife type with an adjustable section that can easily be lowered, allowing the shovel to pass under the trolley wire, without interfering in any way with the efficiency of its operation. The shovel swings through a complete circle delivering the excavated material at any desired point.

A buffer is furnished which takes up the shock that occurs when the shovel strikes a hard piece of excavation. This allows the shovel to be released and relieves the whole machine from the strain to which it would otherwise be subjected.

The illustration shown herewith affords an excellent idea of the class of work being done by the Cleveland Railways Co. and the manner in which the shovel is operated. The length of haul was approximately 6 mi. and the total cost of loading, hauling and dumping was 9.8 ct. per cu. yd.

The shovel is built by the Thew Automatic Shovel Co., of Lorain, Ohio, and the electrical equipment by the Westinghouse Electric & Mfg. Co., of East Pittsburgh, Pa.

Electrical Long-Distance Transmitting, Indicating and Recording System

A NEW long-distance electrical transmitting, indicating and recording system is being placed on the market by The Bristol Co., Waterbury, Conn. In these instruments Bard's patent long-distance induction balance movements are employed. Bristol recording instruments, when equipped with these electrical transmitting systems, are capable of producing automatic and continuous records of pressure, liquid levels, temperatures, mechanical motions, etc., at long distances, even many miles from points at which the transmitters are located.

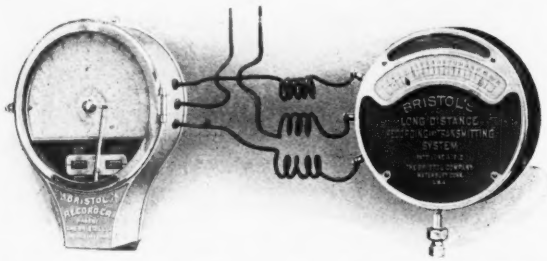


FIG. 1. BRISTOL LONG-DISTANCE TRANSMITTING, INDICATING AND RECORDING INSTRUMENTS

Figure 1 shows a standard unit of these transmitting and recording instruments, including the transmitting indicator for installation at the point where the pressure or temperature, etc., is measured, and the receiving recorder, which is installed at the remote point where it is desired to have the record produced.

The 2 instruments are shown connected by 3 wires, one of which is connected to a source of alternating current, as for instance, a lighting circuit.

The fundamental principle of the Bristol long distance transmitting and recording system is that of the induction balance. The transmitting instrument and the receiving instrument are each equipped with 2 pairs of coils arranged to swing in a horizontal plane over iron cores. Figures 2 and 3 are detailed front and top outline diagrams of the transmitting device which is similar to the receiving device.

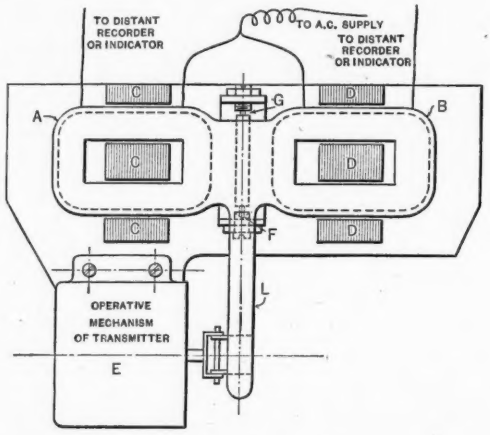


FIG. 2. FRONT VIEW OF TRANSMITTING DEVICE

The complete outfit consists of 2 pairs of mechanically balanced solenoids arranged to swing horizontally back and forth over the ends of soft-iron cores and connected in parallel to an alternating current circuit. One pair of the solenoids is used for the transmitting instrument, the other pair for the receiving instrument. Front view, Fig. 2, of the transmitter shows one pair of the solenoids A and B on spools connected together and supported on a shaft, the ends of which rest in jewel bearings at G and F and free to swing back and forth

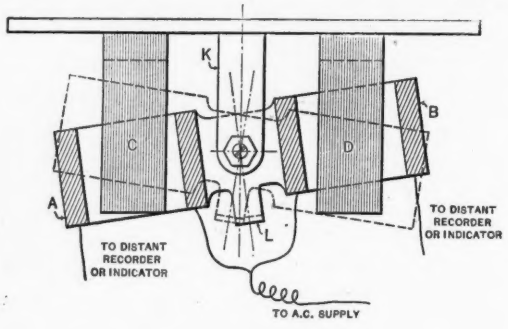


FIG. 3. TOP VIEW OF TRANSMITTING DEVICE

over laminated soft-iron cores C and D. The top view, Fig. 3, shows the solenoids A and B of the transmitter in section and by the dotted outline the position to which the solenoids may swing is also indicated.

A similar pair of balanced solenoids is placed in the receiving recorder or indicator at the distant point. When the solenoids A and B of the transmitter and receiver are connected in parallel to an alternating current circuit and the transmitter coils A and B are held in some certain position by the operating mechanism located at E (water level gage, pressure gage, thermometer, etc.) the relative amounts of current flowing

in solenoids A and B will depend on their positions on the iron cores C and D due to the inductive effect.

At the receiving instrument the other pair of solenoids are mechanically balanced and free to take an angular position, which will be the same as that of the transmitter, since the flow of current will be the same in the corresponding solenoids of the receiver as in the transmitter. If the angular position of the pair of solenoids at the transmitter is changed by the operating mechanism, thus moving one of the solenoids off and the other on to the iron cores, increasing the inductance in one solenoid and diminishing it in the other, the flow of current will be proportionately increased in one coil and diminished in the other. The variations of current at the distant receiver will correspond with the variations at the transmitter, and cause the pair of solenoids of the receiver to seek a position of balance which will be the same as that of the solenoids of the transmitter.

In the transmitter the operating mechanism is linked directly to the balanced solenoids by means of an arm L. In the receiver the recording pen or the indicating pointer is connected to a similar arm through a simple, and practically frictionless multiplying mechanism.

Motor Operated Twin Strainer

THE twin strainer has performed such good service in connection with water supply lines, condensers, etc., that it is now regarded as an essential accessory where continuous service is required.

An important feature of the twin strainer is that it contains but 2 compartments, controlled by 2 gate valves, one compartment being in service, while the other is held in reserve; the reserve compartment is cut into service when the other side becomes fouled, by simply shifting the 2 gate valves, after which the dirty strainer basket can be removed and cleaned, thereby insuring a continuous water supply.

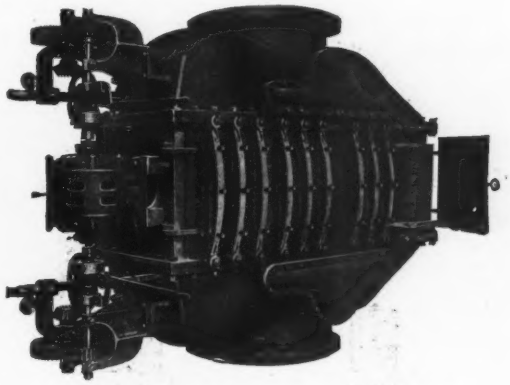
The twin strainer is being rapidly adopted by large users of water, necessitating the manufacture of strainers suitable for pipes as large as 48 in. in diameter. The shifting of the valves on the small strainers by hand is a simple and rapid operation, whereas on the larger strainers, the time consumed in changing over from one side to the other, is quite an item, as well as involving considerable manual labor. To overcome this objection, the Elliott Co., of Pittsburgh, has recently adopted a motor drive applicable to all strainers of 20 in. and above, which is here illustrated.

It will be noted that an electric motor is mounted on one end of the strainer, and drives trains of gears communicating with the 2 valve stems, with friction clutches for controlling each valve stem independently of the other, and also independently of the motor. Each valve stem is provided with an indicating device for indicating the exact position of each valve. The illustration shows one of the baskets on the right-hand side as being partially removed for cleaning purposes. The valves under these conditions, then, would be on the left-hand side, and the indicators would so indicate.

After the baskets are cleaned and replaced and the doors closed, and it becomes necessary to open up the baskets on the other side of the strainer for cleaning; the motor is started up, and after it reaches full speed, one of the lever operated friction clutches is caused to engage the motor shaft, which drives the valve off its seat. This friction clutch is then released and the other friction clutch thrown into engagement with the other shaft, which moves the other valve from its seat. Then both friction clutches are thrown into engagement with the motor shaft, and the valves are moved together to the opposite side of the strainer.

The indicators show the position of the valves at all times in their travel across the valve seats. When the valves are within an inch or so from their seating position, one friction clutch is thrown out of service and the full power of the motor is then employed in seating one valve. After it is seated, its friction clutch is released and the other friction clutch thrown into service, which seats the second valve. The motor is then stopped, the doors opened, and the baskets cleaned.

When it becomes necessary to shift the valves in the other direction, the direction of the rotation of the motor is reversed, and the same operation as above described is repeated.



LARGE TWIN STRAINER WITH MOTOR DRIVE

On a 36-in. strainer, the time required to start up the motors and shift the valves from one side to the other, is actually 61 sec., and the time required to take off the doors and remove the baskets, clean and replace them, on this size strainer, is less than 10 min. This added to the time required for shifting, makes the total time required to clean a 36-in. twin strainer less than 11 min., whereas with the hand operated screws, it would take 3 times as long. The time element in changing strainer baskets is an important one, in order to prevent loss of vacuum and loss of water supply, especially when the water strained contains large quantities of leaves and other foreign substances during high water periods.

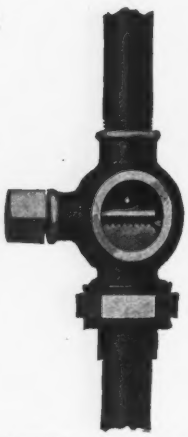
WHITE, FOGGY ice, denoting impurities in the water was traced by Geo. Collister, of Kansas, to the steam condensers, which were of flask type and had been in use several years. Leaks had developed at the flange joint in the bottom of the distributing trough, so that a small amount of raw water was drawn in, by the vacuum formed when a machine stopped for cleaning or inspection, before the vent pipe and check valve could balance the pressure. The leaks were discovered by draining the troughs and putting slight pressure on the condensers. —Refrigerating World.

Effective Cylinder Lubrication

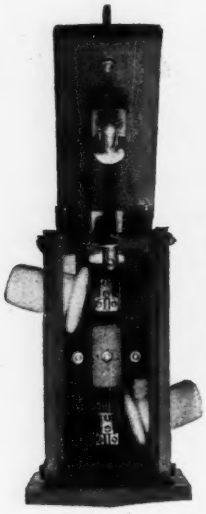
CARELESS feeding of cylinder oil is sure to result in waste, for only such oil as reaches the surfaces of valves and cylinder needing lubrication is of value. If oil flows along one side of the pipe, trickles through valves in a stream and out of the exhaust ports, the waste may run as high as 75 per cent, much of which can be avoided by thorough mixture of oil with the steam.

To insure such a mixture, the Franklin Oil and Gas Co., of Bedford, Ohio, provides the "Franklin Cylinder Oil Carburetor," the action of which is shown in the cut. A spray pipe with 2 rows of small holes at 45 deg. is used for feeding the oil into the steam pipe. Steam passes each side of this pipe, the currents uniting beyond, thus giving a suction action on the holes, and drawing the oil, which has been heated to the temperature of the steam, out in a fine spray, which mixes with the steam. When no steam is flowing, there is no suction, hence the oil will not leave the holes, and no oil will be fed. As the steam current increases, the flow of oil will increase, hence the oil supplied will be in proportion to the load on the engine, subject, of course, to regulation by the feed of the cylinder lubricator.

The makers state that this carburetor, by its mixing action, will so thoroughly distribute the oil that a saving of 50 to 75 per cent can be effected with entirely satisfactory lubrication.



FRANKLIN CYLINDER OIL CARBURETOR



15 AMP. 6600 V. EXPULSION TYPE PRIMARY CUTOUT

New Primary Cutouts

A NEW line of expulsion type, primary cutouts of improved design and having standard ratings of 15 amp. 6600 v., 75 amp. 6600 v., or 100 amp. 2500 v., has been developed by the General Electric Co. for outdoor use.

The main feature of this cutout is the absolute safety afforded the operator in refusing. When the door is opened, the ring bolt and latch are separated from all live metal parts, so that the fuse holder is automatically disconnected from the circuit and is safe to handle.

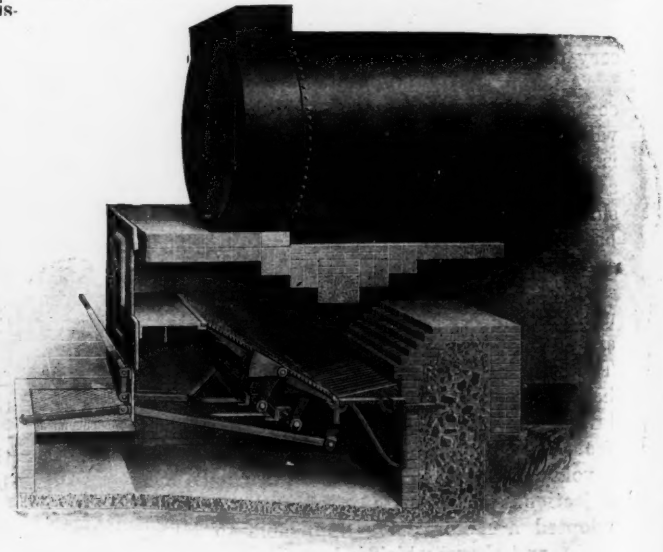
The boxes are constructed of well-seasoned ash, oil-impregnated and further protected from the weather by an outside coat of black japan.

On the bottom of the box is an indicator in the form of a brass card receiver placed over the gas outlet of the expulsion fuse. Into this receiver can be slipped a white card, a square of oiled paper or a thin sheet of white celluloid, forming a white target against the black background of the box that can be readily seen from the ground. The blowing of the fuse causes a discharge of gas from the end, which dislodges the card from its receiver, thus indicating the condition of the fuse from a considerable distance.

The National Smokeless Stoker Grate

COMBUSTION of the coal on a National smokeless stoker grate is carried on in 3 stages, each stage being upon a distinct part of the grate. This is made possible by placing the grate on an incline and providing it with fuel pushers which advance the fuel from the front to the rear of the grate as combustion proceeds. Green coal is thrown on the dead plate in large quantities where it becomes heated and the volatile matter is driven off, mixed with air which enters through small holes in the dead plate. These gases are burned as they pass over the incandescent fuel bed under hot ignition arches and by this arrangement, it is claimed, any grade of coal can be burned upon this grate without the production of smoke.

After the coal has become coked, it is pushed forward, coming gradually to the incandescent zone, and finally being pushed upon a dump plate, where combustion is completed, after which, by means of a lever, the refuse is dropped into the ash pit.



SECTION THROUGH THE NATIONAL SMOKELESS STOKER GRATE

As previously stated, the grate is on an incline and has 2 sets of fuel pushers operated by hand levers. Each set is made up of a series of sector shaped bars pivoted on trunnions resting on recesses in the stationary bars. The pusher elements normally are flush with the grate surface, but are raised through spaces in the stationary grates when it is desired to push the coal toward the rear; the elements are of such size and shape that they fit closely in the slots and prevent fine coal from falling through.

At the rear of the grate, the dump plates are pivoted back of the center and when operated by the lever at the front of the furnace give a large opening for the clinker and ash to drop through to the ash pit.

In the operation of the furnace, the fire doors are opened at comparatively long intervals, as there is space for quite a large quantity of coal on the dead plate. When the coal is nearly consumed, it is pushed to the dump plate, where combustion is completed, and ordinarily the cleaning of the fire consists simply of dumping the ashes into the ash pit; when clinkers form, they are pushed upon the dump plates instead of drawing them through the fire door, as is done with hand-fired grates. The furnace is worked almost entirely with the openings over the grate closed, thus eliminating losses due to cool air entering combustion spaces.

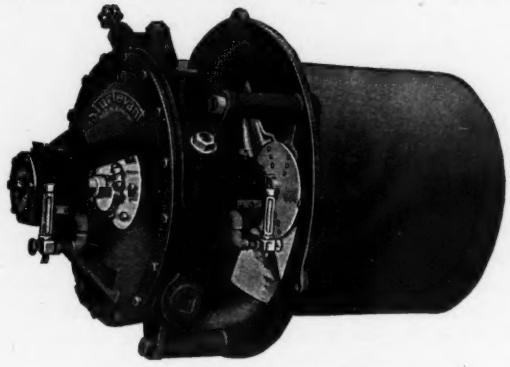
The stoker grate may be installed entirely under the boiler or may project in front, as illustrated. In the latter case, the extension is incased in steel and the space between the casing and the brickwork is packed with 1 in. of magnesia, reducing heat loss by radiation and preventing air leaks through the furnace walls.

This furnace is the product of the New Albany Mfg. Co., New Albany, Ind.

Sturtevant Turbo Undergrate Blower

B. F. STURTEVANT CO., Hyde Park, Boston, Mass., has just completed a new design of undergrate blower for use in places where more draft is needed, and to be placed in the boiler brick work.

In this set, the turbine is of high grade, almost identical with the standard Sturtevant turbines, having



TURBO UNDERGRATE BLOWER

substantial bearings provided with oil ring lubrication, and oil reservoir, which once filled, will last for weeks.

There is also a floating metallic stuffing box, which prevents steam from getting into the bearings and enables a back pressure of 15 lb. to be carried. The casing has been made very large, eliminating back pressure and tending to lower steam consumption.

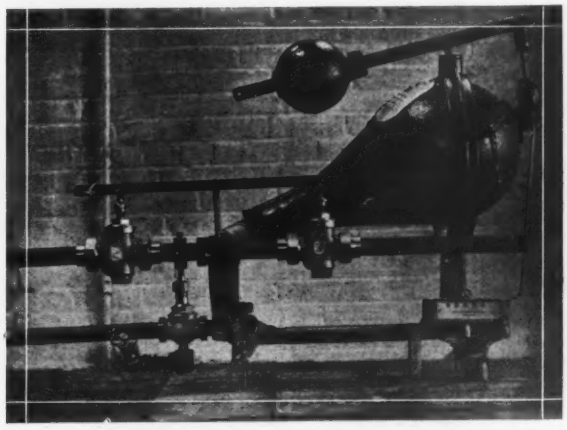
The new machine has nozzle control, using from 1 to 6 nozzles, according to the amount of steam required, thus obtaining high efficiency and minimum steam consumption at low loads.

Balanced Valves for Trap

FOR the 3rd prize in the Mason Photographic contest, the following letter from W. H. Odell was chosen by the judges appointed by the Mason Regulator Co.

June 19, 1914.

"Some years since, a client wanted a steam trap, of the return type, that would eliminate the weighted check valve and spring relief valve such as was in common use at that time. I saw that, to accomplish this result, I would have to place balanced valves in both the delivery and inlet pipes and alternately operate them by the rise and fall of the receiving tank.



BALANCED VALVES OPERATED BY STEAM TRAP

"The question then became, where could I get balanced valves that would operate with least expenditure of force, and at the same time keep tight under very great changes of temperature and pressure? After due consideration, I secured a "Tilt" trap for the trial, and replaced the ordinary check valves as used on all types of return traps, with Mason valves, and arranged a lever as shown by the photograph; this worked to perfection. The tests were made by letting the trap fill and empty 10 times, and then weighing the 10 "dumps." This test was repeated 3 times without any perceptible change in the weight of water used. This was an entirely new departure in steam trap practice for which the U. S. granted me Patent No. 837,711."

THAT FULLY 25 per cent of the accidents to workmen are caused by insufficient lighting for men working at night, is the opinion of experts who have made a study of the subject. It is estimated that $250,000,000 is the average annual cost of injuries to workmen in the United States alone, and that over 50 per cent of these accidents are preventable.—Popular Mechanics.

Simplex Seatless Blowoff Valves

AS shown in the accompanying illustrations, this valve consists of a heavy iron, bronze or steel body and bronze or steel yoke containing hollow plunger, S, follower glands, F, and packing, P. By means of a non-rising hand wheel, the valve may be opened or closed by raising or lowering plunger, S, which, when in its extreme lower position, causes shoulder S to engage loose follower gland F thereby compressing packing P above and below the port, making the valve tight.

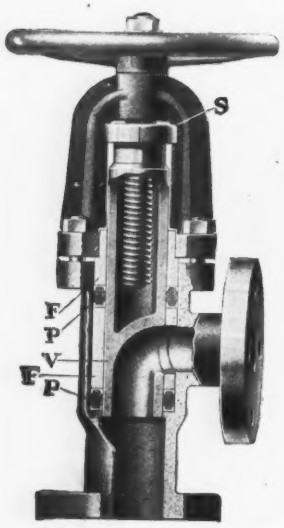


FIG. 1. OPEN POSITION OF SIMPLEX BLOWOFF VALVES

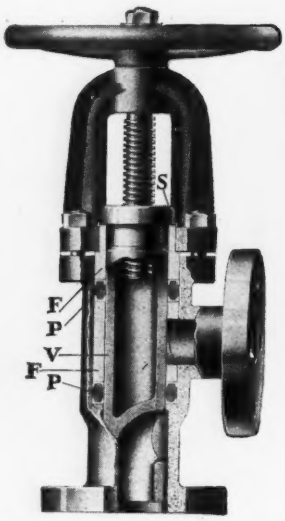


FIG. 2. CLOSED POSITION OF SIMPLEX BLOWOFF VALVES

Due to the form of construction employed, it is stated that all valve seat troubles are avoided, thus eliminating that source of expense and trouble.

Simplex Seatless Blowoff Valves are made by Yarnall-Waring Co., of Philadelphia, Pa.

Oil Switches for Manhole Service

TWO new types of manhole switches for mounting on flat vertical surfaces have recently been developed by the General Electric Co.; one of these is for operating by hand and the other by a solenoid, which is an integral part of the switch. They can be used in locations where there is danger of flooding.

In the hand operated switch are 2 bell chambers through which run the leads to and from the switch. This chamber is of the usual construction and, after the leads are connected to the switch terminals, is filled with an insulating compound and made air tight. The bell chambers as well as the oil vessel and cover are cast iron, bolted to the cast-iron switch frame, the joints being made water tight by gaskets. The operating handle is outside the frame and can be operated by a hook from the entrance to the manhole, the shaft handle passing through a stuffing box.

As a rule, the solenoid operated switch is operated from the central station by the usual control switch, located in the station. The mechanism is especially simple, the plunger of the solenoid being connected direct to the crosshead attached to the operating rods. The switch solenoid uses current only while the switch is in the act of closing or opening by means of the tripping coil, as the switch is held closed by a catch, which allows the switch to open by gravity when the catch is thrown out of position either by the trip coil plunger or by a small tripping lever located outside the switch frame.

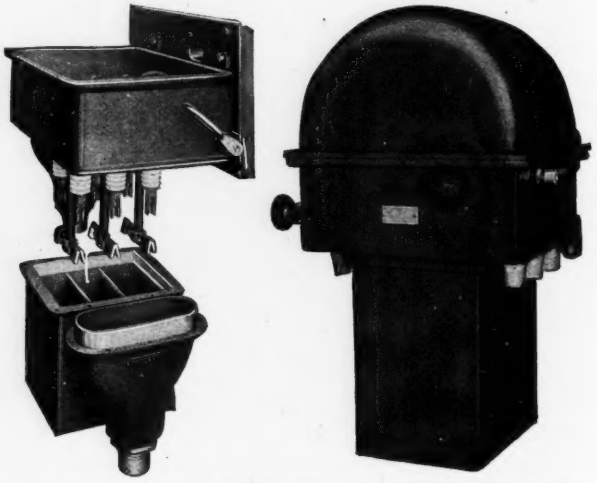


FIG. 1. TRIPLE-POLE SINGLE-THROW 10,000-V., 200-AMP. OIL SWITCH WITH SPECIAL BELL CHAMBER FOR ENTRANCE LEADS

FIG. 2. TRIPLE-POLE SINGLE-THROW 2500-V. 300-AMP. SOLENOID OPERATED OIL SWITCH

Both hand and solenoid operated switches have an indicator which can be seen from the top of the manhole and shows whether the switch is open or closed.

Quick Response from Banked Fire

IN a test made recently at the Scott St. Steam Station of the Toronto Electric Light Co., Ltd., at Toronto, a 554-hp. B. & W. boiler equipped with a Riley stoker was brought up to 354 per cent of rating in 7 min. This remarkable performance was made possible by the moving grates of this type of underfeed stoker. When starting up the stoker, the moving grates also start, breaking up the fuel bed so that the air enters quickly for active combustion.

Before starting this test, the boiler was on a live bank; that is, the boiler pressure was just below the normal pressure of 150 lb., and sufficient coal was being fed to maintain this furnace condition. When conducting this test, a man stationed in front of the boiler gave the signal to start the stoker fan when the steam pressure had dropped 5 lb. below normal, and this was taken as the time of starting the test. The load on the boilers was figured from switchboard kw., figuring back through the turbine water rate corrected for radiation losses. The turbine water rate was checked by a Worthington hot water meter in the feed line. The turbine was called in at 9:36 a. m.; reported ready for load 3¾ min. later. It was synchronized 41½ min. past 9, but the stoker fan had started at 9:39. The fire became so

active that at 9:44, the kw. load was 900, which was equivalent to 95 per cent of boiler rating. A few minutes later, the kw. load was 1700, which was equivalent to 201 per cent boiler rating; at 9:46, 7 min. after the stoker and fan started, the kw. load was 3000, or 354 per cent of rating.

This plant is used as a reliability reserve or "standby" for the hydro-electric power generated at Niagara Falls. It is maintained at all times with a live banked fire in a boiler furnace and is in readiness to pick up the load in case of interruption to the hydro-electric power supply. This steam station contains 4 554-hp. B. & W. boilers, each equipped with a 6-retort Riley self dumping underfeed stoker. Forced draft for the 4 stokers is supplied by a Sturtevant double width No. 10 Multivane blower, driven direct-connected by 125-hp. d.c. motor.

Books and Catalogs

POWER, HEATING AND VENTILATION. PART I. By Charles L. Hubbard. Second edition, 299 pages, illustrated; New York, 1914; price $2.50.

This volume is the first part of a treatise covering the design, construction and management of power, heating and ventilating plants.

The matter contained in this volume covers in a simple and concise manner the design of small and medium size steam power plants, starting with a detailed discussion of the fundamental elements of the subject and leading up to the proper selection of equipment and its assembly in the plant.

Particular attention is given to the subjects of boiler horsepower types and design of boilers followed by chapters on boiler furnaces, boiler settings, chimneys, mechanical draft and boiler accessories. A brief description of various types of engines and turbines is given in Chapter X, while the remainder of the book deals with auxiliary apparatus, pipe fittings and valves, details of power plant design and the care and management of boilers and engines.

Noteworthy features of this volume are the number of tables it contains and the clear illustrations accompanying the text.

POWER, HEATING AND VENTILATION. PART II. By Charles L. Hubbard. Second edition, 308 pages, illustrated; New York, 1914; price $2.50.

The second volume of this treatise covers the subject of heating and ventilation as applied to all classes of buildings from the small furnace-heated dwelling to structures of the largest size.

Fundamental elements of heating and ventilation are treated in the first few chapters. This is followed by a discussion of furnace heating, boilers, pipe, fittings and valves, and the various methods of steam and hot-water heating in use at the present day. A short chapter on electric heating describes the various types, materials used and method of connecting these heaters together with a comparison of cost of steam and electric heating.

Fans, forced blast heating and ventilation, special devices, the methods of heating and ventilating different types of buildings and the care and management of heating and ventilating plants are taken up in detail.

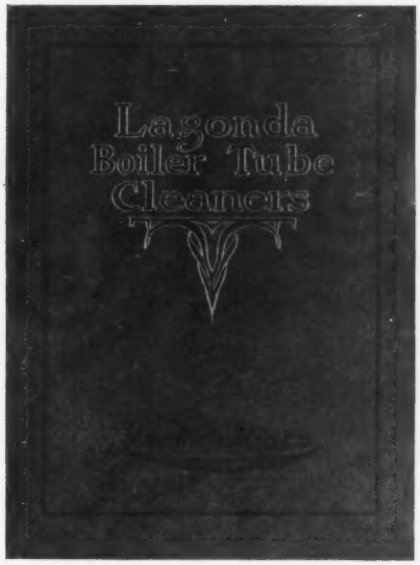
This volume, like Part I, contains many valuable reference tables on the subject treated.

SEVERAL TYPES of feed water regulators are described and illustrated in a bulletin recently issued by the Elliott Co., 6910 Susquehanna St., Pittsburgh.

BULLETIN NO. 119, just received from The Goulds Mfg. Co., Seneca Falls, N. Y., illustrates and describes a new type of the company's centrifugal pumps, with instructions for installing and operating.

ARMSTRONG CORK CO., Pittsburgh, Pa., has just published a booklet entitled "Permanent Fortifications," which contains some facts regarding the value of good heat insulation.

THE LAGONDA MANUFACTURING CO. has recently issued its catalog L-8 dealing with the subject of Lagonda Boiler Tube Cleaners. The catalog is well illustrated and the various types of tube cleaners are described in detail, explaining clearly their method of



operation and advantages. These cleaners are made for use in all types of boilers used in power plants and the interior of the catalog is as attractive as the cover, a reproduction of which is shown herewith.

THE UNIVERSAL UNAFLOW engine bulletin of Skinner Engine Co., Erie, Pa., discusses the Unaflow principle, and the origin and advantages of the Universal Unaflow engine. Illustrations show the action of the engine operating condensing and noncondensing.

BULLETIN NO. 45,602, just issued by the General Electric Co., deals with the subject of the protection of series lighting circuits by lightning arresters. The arresters described are of 2 types, the horn and the aluminum. The former is designed for the protection of series transformers and rectifiers against lightning discharge and similar trouble, and the latter particularly for the protection of cable circuits running from series arc rectifiers. Illustrations and dimension diagrams on the various arresters are included in the bulletin.

SMALL TURBO-GENERATOR SETS is the title of a bulletin recently issued by the General Electric Co., describing its small steam turbine driven alternating and direct-current generating sets in sizes ranging from 7 to 300 kw.

CONCRETE PILE STANDARDS is the subject of a pamphlet discussing the following topics: Standard details for reinforced concrete pile caps, comparison of cost of concrete and wooden piles under various soil conditions, method of testing a concrete pile and how a pile supports its load.

This pamphlet is published by Hunley Abbott, 11 Pine St., New York City.

GARDNER DUPLEX power pumps are illustrated in Circular P-8 from The Gardner Governor Co., Quincy, Ill.

Other circulars from the company are as follows: P-3, on Gardner duplex steam pumps; G-R2, Gardner-Rix vertical air compressors; A-C5, Gardner horizontal single-cylinder air compressors.

COCHRANE MULTIPORT VALVES, a booklet of 72 pages, just issued by the Harrison Safety Boiler Works, Philadelphia, describes the multiport valves introduced by that company for back pressure, relief and vacuum service, flow service in connection with mixed flow turbines, and check valve service with bleeder or extraction turbines. In addition to full descriptive and tabular matter the book contains numerous diagrams and layouts, also data on the effects of air in condensers and upon turbine performance.

A PUBLICATION devoted solely to centrifugal pumps is being distributed by the De Laval Steam Turbine Co., of Trenton, N. J. This book of 298 pages, contains over 300 illustrations. The text matter is divided into chapters under such headings as "The Introduction of the Centrifugal Pump and the Work for Which it is Adapted"; "Features to be Considered in Selecting Centrifugal Pumping Equipment"; "The Use of the Characteristics Curve"; "Methods of Testing Centrifugal Pumps," etc. Tables and charts are given for determining the resistance of pipes and the relation between heads and spouting velocities. The investigation of the pumping problem, together with drawing up of specifications for centrifugal pumps, are also treated at some length.

BULLETIN NO. 44,300, just issued by the General Electric Co., illustrates and describes some of the Gas-Electric Motor Cars and Locomotives built by that company.

These cars and locomotives are adapted to branch line service on steam roads and also for interurban service. The prime mover is a gas engine, direct-connected to an electric generator which supplies current to the motor mounted on the axles of the front truck. The controller contains the necessary handles for regulating the generator voltage, controlling the motors, and for throttling the engine and reversing the motors. The power equipment is described in considerable detail in the bulletin and average cost of operation of the standard car is given, in addition to other data relative to weights, dimensions, etc.

PRACTICAL ENGINEER

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POSITION WANTED—By young man, age 22, as Oiler or Assistant Engineer. I. C. S. graduate Steam-Electric course. Four years' experience as quarry Hoisting Engineer. Good reference. Oscar Malila, Troy, N. H. 2-1-1

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WANTED—Three capable men to represent the Hulson Grate Co. in the following states: one in states of Ohio and Michigan, one in Wisconsin and Minnesota, and one in Kansas and Nebraska. If you have ability to sell the best grate on the market write the Hulson Grate Co., Keokuk, Iowa. 2-1-1

WANTED—To handle high-grade boiler specialties to be sold on a make-good basis. Engineers or others will find profitable to have an agency for their full or spare time. For particulars address Budd Grate & Fdry. Co., 2013 E. Letterly St., Philadelphia. 2-1-1

WANTED—Resident subscription agents in all cities of 50,000 population, and over. Many of the largest cities still open. An excellent chance for hustlers to turn their spare time into dollars. Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—ALL STEAM USERS to have clean boilers without using compounds or chemicals in any form. Write "Otis," No. 317 Norfolk Ave., Buffalo, N. Y. tf.

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WANTED—To buy or a place to build an Electric Lighting plant in good sized town. Address Box 384, Practical Engineer, Chicago, Ill. 2-1-1

WANTED—Agents to sell my Graduated Calipers, Pocket Levels, etc. Liberal commission. Ernst G. Smith, Tampa, Fla. 2-1-6

Help Wanted

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Company. Springfield, Ohio. tf.

HELP WANTED—Engineer wanted for Ice and Cold Storage plant in State of Pennsylvania. State salary wanted. Address Box 385, Practical Engineer, Chicago, Ill. 2-1-1

WANTED—Agents handling engine and boiler-room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Address Practical Engineer, Box 381, Chicago, Ill. tf.

For Sale

FOR SALE CHEAP—One Second-Hand Buckeye Engine; 125 h.p.; 9-ft. x 15-in. Band Wheel. Good condition. Appleton Mfg. Co., Batavia, Ill. 1-15-2

FOR SALE—Direct current, 125-volt, direct-connected units; 9 k.w. Crocker Wheeler with Reeves engine, $250; 20 k.w. Ridgway with Ridgway engine, $350; 25 k.w. General Electric with Harrisburg engine, $400; 35 k.w. General Electric with Harrisburg engine, $650; 35 k.w. DeLaval turbine, $450; 50 k.w. Sturtevant with Sturtevant engine, $750; 75 k.w. General Electric with Harrisburg engine, $1,000; 50 k.w. Westinghouse with Westinghouse gas engine, $1,200. Duzets & Son, 50 Church St., New York, N. Y. tf.

FOR SALE—Grobet Swiss Files are the standard of excellence in files, and have been for over 100 years. We send post paid, as an introducer, 48 files especially adapted for tool makers and machinists on receipt of $5.00. This is a chance to get a set of files you'll appreciate and we'll get future orders. Montgomery & Co., 101 Fulton St., New York, N. Y. 2-1-1

FOR SALE—Steam Hammer, 750 lb. Bement Niles, excellent condition; will sacrifice to move quick. Have large stock machinery of all kinds. Send us your inquiries. Zelnicker Supply Co., St. Louis, Mo. tf.

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ENGINEERS' POCKET MANUAL, 175 pages, edited by University of Tennessee, will be mailed every subscriber sending in NEW subscription (not your own) to Practical Engineer. Gilt edges; bound in leather.

Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

Sparks From The Advertising Pages

A statesman who was noted as much for his shrewdness in business affairs as for his political wisdom, once said that the feature which marks off the successful from the unsuccessful man in any line of work is "intellectual"interest. Not "money" interest first, but interest in one's work simply as work.

There's a valuable hint here for all of us in these days when eagerness to make money—more money—often leads people to overlook the very means by which money may be made. For it is clear that to concentrate narrowly on one's work, is a sure way to make that work ineffective. The worker who would be successful, must know his own work in relation to other work in the same field—must study his methods, his equipment, his tools in the light of what is being accomplished by others. He must be alive to progress in his chosen sphere of work. In a word, he must have "intellectual" interest.

This kind of interest may come from a strong natural bias toward some particular line of effort. But it may also be cultivated by any one who realizes its importance. For instance, the engineer who is in danger of falling into a rut—and so diminishing his earning capacity—should seize every opportunity to keep himself "posted" on engineering "news," improvements in machinery, new devices for increasing efficiency or lessening expense in a plant—anything and everything new that is good and helpful.

Good and helpful—that is the point. Now, there is probably no more direct road to what is really valuable among the output of new engineering suggestions, than the advertising pages of this magazine. Why? Simply because the advertisers, as sensible men, are not going to spend money in drawing the attention of the public to machinery and devices of doubtful utility.

"Fake stuff" is of course still advertised in some newspapers and magazines, though in immensely smaller volume year after year. But we can answer for it that the scores of advertisers who use "Practical Engineer" are too experienced, to say nothing of their being too honorable, to advertise even the least expensive specialty which has not solid utility behind it.

You see, then, that our advertising pages supply you with "sifted" news—news freed from every element of doubt or suspicion. Not only that, but it is news prepared for you with very great care, so that it may put you in possession of the essential facts as quickly as possible.

Whether, therefore, your aim in reading the advertising pages is to find and buy something that will help you in your work, or whether you are simply seeking to keep bright and keen that "intellectual" interest which is the basis of success, you will be well rewarded for the time spent in reading them.

But let it be noted that the best results from reading the advertising pages are derived from systematic, close, observant study of them. Don't skip and don't hurry. Skipping may leave unnoticed just the very suggestions that would spell progress for you. Hurrying may convey a wrong impression of the construction or practicability of the new machine or device.